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AN INITIAL INVESTIGATION OF THE EFFECT OF REPEATED HIGH INTENSITY FLASHES ON MAN'S PERFORMANCE OF A TRACKING TASK

DARCOM Intern Training Center

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AN INITIAL INVESTIGATION OF THE EFFECT OF REPEATED HIGH INTENSITY FLASHES ON MAN'S PERFORMANCE OF A TRACKING TASK

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Final Report

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This paper is a report of research designed to investigate the effect of repeated glare on human performance of a tracking task.

The experiment used an EAI 680 computer to create the tracking task as well as to record the experimental data. Subjects were dark-adapted for thirty minutes and then performed the tracking task for a half hour run period. During the run the subject experienced four flashes from a glare source. A control run, with no dark-adaption or intermittent flashes, was performed by all five subjects. Performance was measured by the time required to reach a predetermined level of

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error, while a biological factor was measured by the lowest galvanic skin resistance value during the time period prior to reaching the error level.

Statistical analysis showed both the flash-time factor and the condition flash-time interaction to be significant at the 95% level of confidence. Graphical analysis showed the subjects' performance to increase with time while operating the tracking task under the glare condition.

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FOREWORD

The research discussed in this report was accomplished as part of the Maintenance Engineering Graduate Program conducted jointly by DARCOM Intern Training Center and Texas A&M University. As such, the ideas, concepts and results herein presented are those of the author and do not necessarily reflect approval or acceptance by the Army.

This report has been reviewed and is approved for release. For further information on this project contact Dr. Ronald C. Higgins, Chief of Maintenance Effectiveness, Red River Army Depot, Texarkana, Texas.

Approved:

Ronald C. Higgins

Dr. Ronald C. Higgins, Chief
Maintenance Effectiveness Engineering

For the Commander

James L. Arnett

James L. Arnett, Director
Intern Training Center

ABSTRACT

Research Performed by Martin E. Winkler

Under the Supervision of Dr. R.S. Morris

This paper is a report of research designed to investigate the effect of repeated glare on human performance of a tracking task.

The experiment used an EAI 680 computer to create the tracking task as well as to record the experimental data. Subjects were dark-adapted for thirty minutes and then performed the tracking task for a half hour run period. During the run the subject experienced four flashes from a glare source. A control run, with no dark-adaption or intermittent flashes, was performed by all five subjects. Performance was measured by the time required to reach a predetermined level of error, while a biological factor was measured by the lowest galvanic skin resistance value during the time period prior to reaching the error level.

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ACKNOWLEDGMENTS

I wish to thank Dr. R.S. Morris for serving as my committee chairman and for his assistance throughout this project. I further wish to thank the other members of my committee, Dr. J.M. CoVan and Dr. S.B. Childs, for their constructive criticisms and other assistance.

Also, Robert Ferguson and Dennis Boyer contributed much by providing advice and alternatives in designing the computer algorithm used for the project.

During the course of this work, I was employed by the U.S. Army as a career intern in the DARCOM Maintenance Effectiveness Engineering Graduate Program. I am grateful to the U.S. Army for the opportunity to participate in this program.

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CHAPTER I

INTRODUCTION

In many aspects of man-machine relations, vision is an important physical criterion. Be it repairing, operating, or installing, vision is often necessary for successful completion of the task. In realizing this, man has made great efforts to ensure proper lighting, However, as is often the case, solving one problem tends to either create or compound another.

The highway lights on an automobile are of great service to its driver, but to the driver of an oncoming car, they can be just as great a problem. In a Minnesota roadside study it was found that highway traffic accidents were higher in areas having more glare sources (17)*. Highway sections having higher frequencies of intersections and advertising signs, also showed higher accident rates. A common factor of all the higher accident areas was a greater number of glare sources; both reflected from the road signs and scattered from approaching cars.

The problem to be investigated in this paper is that of the effect of repeated glare of high intensity flashes on human performance. A tracking task was employed to stress the subjects, with the time to reach a predetermined level of error and galvanic skin resistance used as two separate measures of the effect.

The design of the experiment includes a control group, as well as, an experimental group. Both groups underwent the same procedure, with only the intermittent glare source removed for the control group.

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*Numbers in parentheses refer to citations in the List of References.

The test involved the use of a number of dark-adapted subjects to operate a two dimensional tracking simulator under a normally low level of illumination. In its final configuration the tracking-simulator was a Cathode Ray Tube (CRT). The target to be tracked was an illuminated dot which moved about the center cross-hairs of the CRT in a random manner. The subject, seated approximately two feet from the CRT, used a joy stick with two degrees of freedom to track the target deviations. The subject's displacement of the joy stick in the proper direction causes the target to move to the intersection of the cross-hairs at the center of the screen. Since the target was continuously driven along a random path, it was necessary for the subject to make similarly continuous movements with the joy stick to keep the target at the center of the CRT (zero positioning). At intervals throughout the test, a high intensity whitelight was flashed in the subject's line of sight. If at any time the subject allowed the target deviations to exceed a predetermined displacement, a buzzer sounded and continued to do so until the target was back within the allowable range. The buzzer served as additional feedback to the subject and provided an additional stress.

The subject's performance, total buzzer time, and galvanic skin resistance were monitored for future analysis. Finally, the subjects completed a questionnaire concerning the tracking task.

CHAPTER II

REVIEW OF LITERATURE

Bartlett (1951) reported that a group of R.A.F. pilots were studied in simulated Spitfire cockpits. The most significant finding of this study was the general tendency for an increase in errors at the end of a flight. "A tired airman, it seems, has an almost irresistible tendency to relax when he nears the airport." (19) This condition could be explained by the inverted 'U' curve (Figure 1).

The Inverted U Hypothesis states that as stress increases, the resulting arousal increases, and performance consequently improves up to an optimal point, and thereafter declines. This relationship between stress and performance is entirely qualitative. Its use is therefore limited to detecting trends and patterns in data obtained under closely controlled conditions. Also, very little is known as to how the optimum point moves (or even if it does) as a subject's arousal is raised and lowered successively over a period of time. (25) For this experiment the inverted U curve may offer an explanation of time related changes in performance, pending the conditions of those changes.

Any experiment that places a demand on a subject over a period of time must consider fatigue as a possible factor. Fatigue can be of two types; muscular or general. General fatigue is defined by different authors according to either the caustive factors or the particular affected physiological parameters. Visual fatigue, nervous fatigue, and fatigue caused by monotonous work are all specific classifications of general fatigue. (10)

McFarland has shown that, although fatigue is different for the

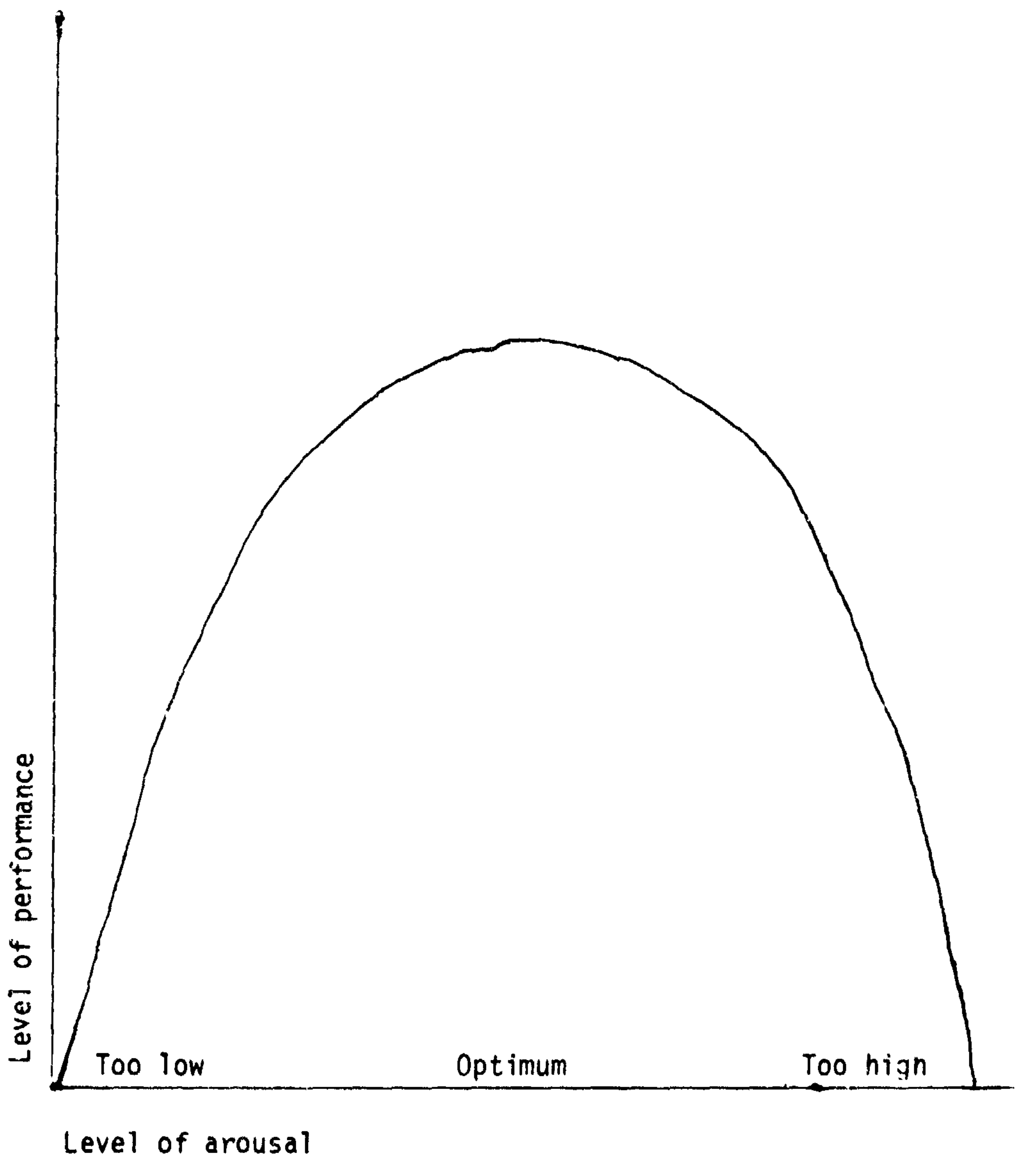

Figure 1.

Inverted 'U' Curve (25)

different physiological systems, it is possible to fatigue other seemingly unrelated systems through the application of stress at some other point in the bio-system. (20) This result can be seen in experiments involving very exhausting work. As an example, it was found that, in severe exercise on a bicycle the subject's adaptation and mental performance deteriorated as well as their physical ability to operate the bicycle exercise. This result indicates that any fatigue determined to exist during operation of the tracking task may be the consequence of some factor other than the said operation.

Krivohlavy (19) in a paper dealing with fatigue in industry, cited numerous studies which utilized vision as a measure of fatigue. Specifically, it was found that pupil diameter, as well as visual acuity, showed a marked decrease over time during fatiguing activities. Krivohlavy found that vision tests measuring perceptual performance in a self-paced situation, taken at various times during a work shift, steadily diminished during the shift. The question left unanswered by Krivohlavy's study is, whether fatigue of the musculature is being measured by changes of the visual capabilities or if it is actually the visual system which is being fatigued. This experiment uses statistical methods to determine what factors effect the subject's performance.

Of studies concerned with the consequences of adverse lighting, few consign fatigue as a direct function of improper illumination. Numerous highway studies have examined the relationship between proper street lighting and accident rates but again, most are reluctant to consider driver fatigue as the result of too much or too little lighting.

Efforts to measure fatigue by performance have, in the past, been relatively unsuccessful. C. Cameron (5) stated in a report on fatigue

that a driver shows no significant deterioration in performance until after he has been working continuously for periods of 16 to 20 hours. Numerous other test results show similar time intervals. It seems then, that initially the effect of fatigue is somehow hidden from simple performance measurement. Some experimenters suggest that in laboratory studies subjects tend to compensate for adverse conditions such as lighting by trying harder. In a report dealing with fatigue in modern life, (20) McFarland states, "What is needed to prevent masking of fatigue is a combined measure of both speed and accuracy." To compensate for this result the subject's galvanic skin response (GSR) was monitored during the experiment investigated in this paper.

In a paper for the Texas Transportation Institute, a drivers GSR was monitored while the drivers operated their automobiles over roadway sections of various illumination levels. (7) The results showed that insufficient, as well as excessive roadway lighting, affected the drivers' galvanic skin resistance.

The GSR, when used properly, can be an indicator of central nervous system events. In 1888 Feré demonstrated that rapid fluctuations in skin resistance could occur in response to emotional stimulation. It is currently thought that these fluctuations are due to a change in the total permeability of a selective cutaneous membrane in response to the arrival of impulses carried by cholinergic sympathetic nerves. (4)

The GSR can, in addition to its emotional information, indicate levels of arousal. Higher levels of arousal are accompanied by lowered skin resistance. Changes in electrodermal reflex are rapid, usually requiring fractions of a second to reach peak values. This rapid response to a given stimulus is in itself another measure of a subject's

psychophysiological state. Ryan and Warner, investigating fatigue and its effects in car drivers, found that fatigue caused a delay in a subject's galvanic skin response. (10)

CHAPTER III

EXPERIMENTAL PROCEDURE

This chapter presents a description of the methodology and equipment used in this experiment. In addition, a presentation of the related statistical methods is included.

Equipment

The subject views the target from a Tektronix Type 556 Dual-Beam Oscilloscope. Seated approximately two feet from the face of the scope, the subject uses a two-dimensional joy-stick to hold the target at the center of the screen. The target is driven by two random signal generators through an EAI 680 analog computer. A circuit diagram is shown in Figure 2.

This circuit has three basic divisions; the display circuit, the error circuit, and the GSR circuit.

The display circuit originates with four track-store amplifiers sampling two random noise generators at a rate of 1.67 samples per second. This random signal is then added to the subject's input. From this point it is integrated and inverted before being displayed through the oscilloscope cross-plot.

The integration operates at a rate of one volt per second per volt-input with the oscilloscope set to scale one centimeter for every two volts-input. Consequently, the target moves at a rate of 0.83cm/sec per volt-input to the integrators.

The error circuit sums the subject's signal and the random signal and calculates the two dimensional mean-square error. When the

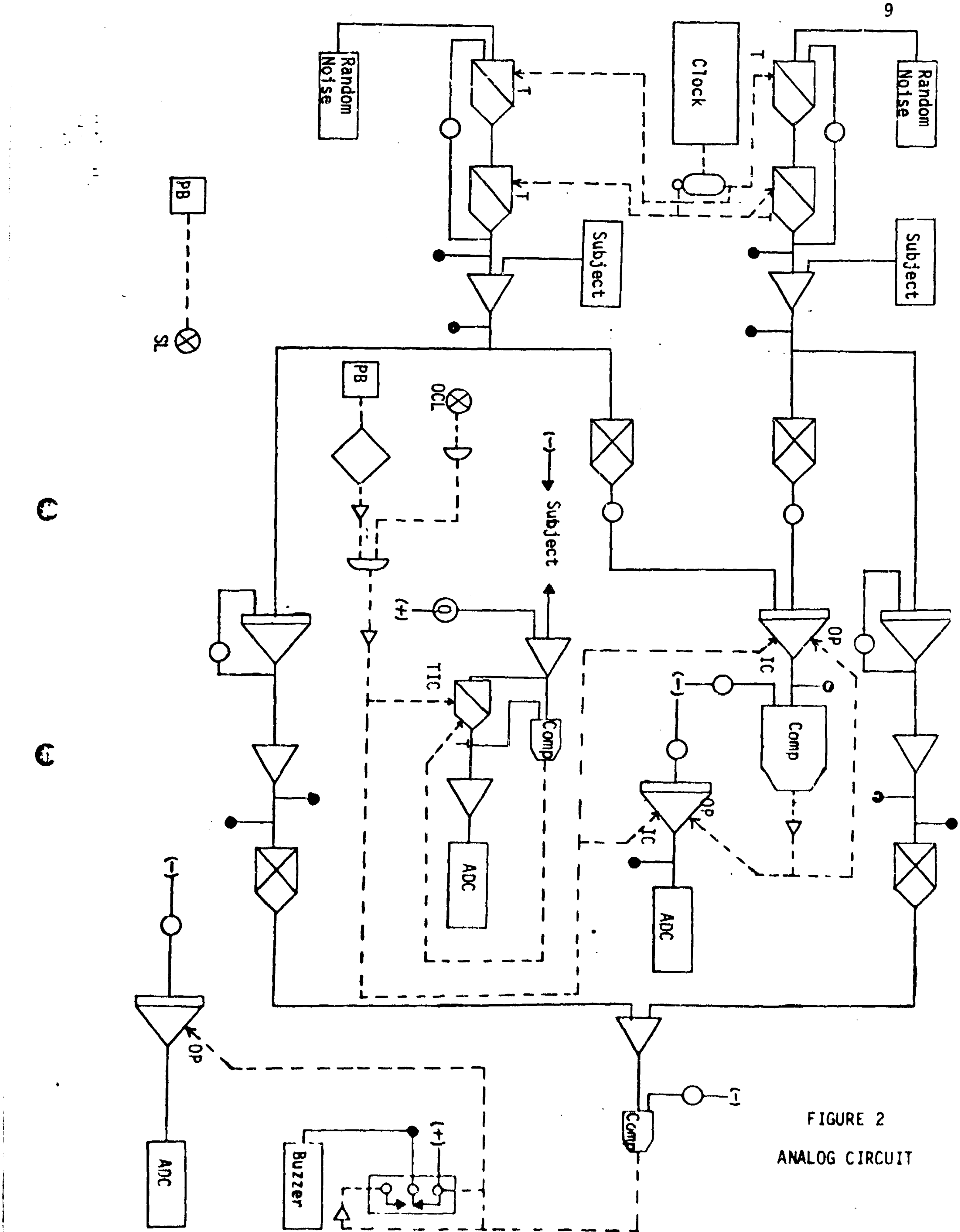

FIGURE 2

ANALOG CIRCUIT

accumulated mean-square error exceeds 0.25 the comparator puts the time ramp in the hold mode while the digital part of the 680 computer reads this value from the time ramp. Once this operation is complete, the error circuit is zeroed and operation is started over. The time ramp and error circuit is also zeroed through the use of a push-button any time a flash from the Porta-Glare occurs. The error circuit also measures the target's distance from center. When target distance from center exceeds one centimeter in any direction, a parallel error circuit sounds a buzzer. The total amount of time the buzzer operates during a run is determined by the use of another time ramp.

The GSR signal is determined by the ten volt complement of the voltage drop across the subject's middle and index fingers. At the start of a run this signal is adjusted by use of a hand-set potentiometer to fall in the range of 1.0 - 1.5 volts. The remaining GSR circuitry determines the peak value obtained during each perturbance of the error circuit. This peak value is recorded along with the time to error data point.

The digital program used to control the analog circuitry is listed in Appendix A. In addition to recording the data this program sets keyboard potentiometers and provides preliminary data analysis. A sample output is included with the programs.

Experimental Conditions

The operation is first explained to each subject prior to a practice run. These runs are continued until the subject is able to control the target without sounding the buzzer for ten consecutive minutes. At this time the GSR electrodes are attached and from one to three runs are made

depending upon allowable time. Runs lasted thirty minutes and took place at all times of the day, depending upon the subjects' availability. Control runs were preceded by thirty minutes adaption time. A minimum of fifteen minutes rest was given between consecutive runs. Following the last run each subject filled out a questionnaire (Figure 3, page 12)

Prior to any run, the subject's part in the experiment is reviewed. This is done by reading a set of instructions (Figure 4, page 13) to the subject. The room was then darkened to effect dark-adaption of the subject's ocular system. After thirty minutes the buzzer is sounded to notify the subject of the end of the dark adaption period and the beginning of operation. The first three minutes of operation are used to refamiliarize the subject with the tracking task. After this time the subject is again notified and the actual run begins.

Runs lasted thirty minutes. During this time, four flashes of four second duration and 800 foot-candle intensity are given from a Porta-Glare unit placed 22 degrees above the subject's line of sight. These flashes occur at five minute intervals with the exception of the last, which comes after a ten minute delay. See time line shown below in Figure 5.

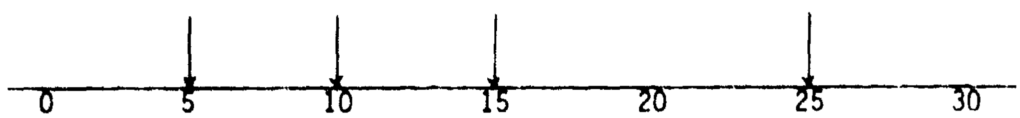

FIGURE 5

RUN TIME LINE (IN MINUTES)
(↓ INDICATES FLASH)

Experimental Design

The experiment for this investigation is a three factor, Latin square design involving both fixed and random effects. (18) The condition

Subject Number __________

Name ____________________

Date Tested _____________

Time of Test ____________

Amount of Practice Time _________

Practice Sample Mean ____________

Practice Standard Deviation _____

Sex ___________

Age ___________

Does the Subject

Wear Glasses _____

Wear Contact Lens ___

Smoke _____

Drink _____

If yes, when was

last time

____

****

Post Run Questions

Did you feel fatigued during a run _______

If so, when ______________________________

What effect did the glare have ______________________

What effect did the buzzer have _____________________

Did you lose sight of the grid ______________________

Did you lose sight of the dot _______________________

If so, when ______________________________

Was any color better than the other __________________

Best _________

Worst ________

****

COMMENTS:

FIGURE 3 DATA SHEET 1

At the beginning of the experiment you will be given thirty minutes in which to become accustomed to the control of the equipment.

The control stick at your right hand controls the movement of the dot on the screen. If you move the stick back the dot moves up, if you move the stick forward the dot will move down, moving the stick to the right and left will cause the dot to move in that direction. Your objective is to hold the dot on the cross hairs of the screen, or as close as you can.

At the end of your practice run you will be placed in a darkened room for about thirty minutes in order to allow your eyes to become dark adapted. After this time the buzzer will sound and you will be given two minutes of practice time, and then the operators will place the analog computer into the initial condition mode for fifteen seconds. This will move the dot to the center of the screen and hold it there. At this time the machine will be placed into the operate mode and will begin taking data.

During the run there will be from two to five flashes, with each run lasting approximately thirty minutes. At the end of the run an operator will change the filters on the screen. You will then be given a short rest period to readjust your eyes to the room and the next run will begin.

If you have any questions ask the operator at this time.

FIGURE 4

INSTRUCTIONS

SHEET 2

sequence for each subject is determined by first assigning each condition a numerical range. Conditions are then assigned, using a random numbers table, subject to the stipulation that each subject must experience each experimental condition. The resulting Latin square is shown in Figure 6. All subjects used were selected from engineering graduate students.

With this experimental structure the subjects are not considered as repeated samples. Rather, each subject is treated as a different experimental level. The repeated factor within the block is the flash from the glare source. Data points shown in the block of Figure 6 represent the number of perturbances from the start of the experiment to the time of the flash.

For purposes of analysis, the subjects are later treated as repeated samples In this case the data is standardized for each subject-condition.

Statistical Methods

For this experiment the error term is represented by the value of T in the equation:

$$K = \int_0^T (X^2(t) + Y^2(t))\, dt$$

where

K = predetermined level of error (0.25),
T = time to error,
X^2 = X component of mean-square error as a function of time,
Y^2 = Y component of mean-square error as a function of time.

The first step taken in analyzing the data is to determine the corresponding statistical distribution for the variable T. A plot of ranked T values, on normal probability paper, obtained from subject number four,

SUBJECT NUMBER

	FLASH	001		002		003		004		005	
I	1st	C		16	R	19	O	15	W	31	B
	2nd	O		33		37		31		63	
	3rd	N		47		56		45		95	
	4th	T		81		93		77		159	
II	1st	35*	O	15	B	22	W	27	R	C	
	2nd	61		32		43		40		O	
	3rd	85		47		62		107		N	
	4th	129		77		101		129		T	
III	1st	29	B	C		18	R	19	O	30	W
	2nd	53		O		39		40		51	
	3rd	74		N		58		59		76	
	4th	117		T		95		104		124	
IV	1st	23	R	16	W	17	B	C		28	O
	2nd	46		33		33		O		54	
	3rd	73		49		48		N		84	
	4th	120		65		81		T		138	
V	1st	27	W	17	O	C		13	B	28	R
	2nd	50		34		O		29		57	
	3rd	70		51		N		44		83	
	4th	110		84		T		73		143	

O = Orange Red

R = Red

B = Blue

W = White

CONT = Control

* Numbers indicate the value of the subscript i of T_i corresponding to 1st, 2nd, 3rd, and 4th flash respectively.

FIGURE 6

EXPERIMENTAL BLOCK DESIGN

shows that this distribution is approximately normal (see Figure 7). Appendix B contains a program to rank the data and plot a frequency histogram for the control runs. By comparing the histogram plot for subject number four to the histograms (also contained in Appendix B) for the other subjects, it can be shown that the data taken is approximately normal for all subjects.

The next step in the statistical analysis is to combine a series of the T values to obtain new data. This new data represents the frequency of errors in consecutive 275 second intervals for each subject condition level and is given by Y in the equation:

$$Y = I/\left(\sum_{i}^{I} T_i \geq 275\right)$$

At this point an analysis of variance can be done to determine what factors have an influence on a subject's performance. The first model for analysis (model 1) is a three factor, mixed mode, with no replications. The statistical metrod for this analysis is described in Chapter V of <u>Statistical Principles in Experimental Design</u> by Winer (26).

As applied to this experiment, Winer proposes two experimental models:

(i) $Y_{ijk} = \mu + S_i + C_j + F_k + SC_{ij} + SF_{ik} + CF_{jk} + SCF_{ijk} + \varepsilon_{ijk}$

(ii) $Y_{ijk} = \mu + S_i + C_j + F_k + SC_{ij} + SF_{ik} + CF_{jk} + \varepsilon_{ijk}$

Equation (ii) is termed the additive model, whereas (i) is considered the non-additive model. The term "additive" implies that the components of the three-factor interaction are homogeneous and may, consequently, be considered as an estimate of experimental error.

To determine which model should be used, the variation due to

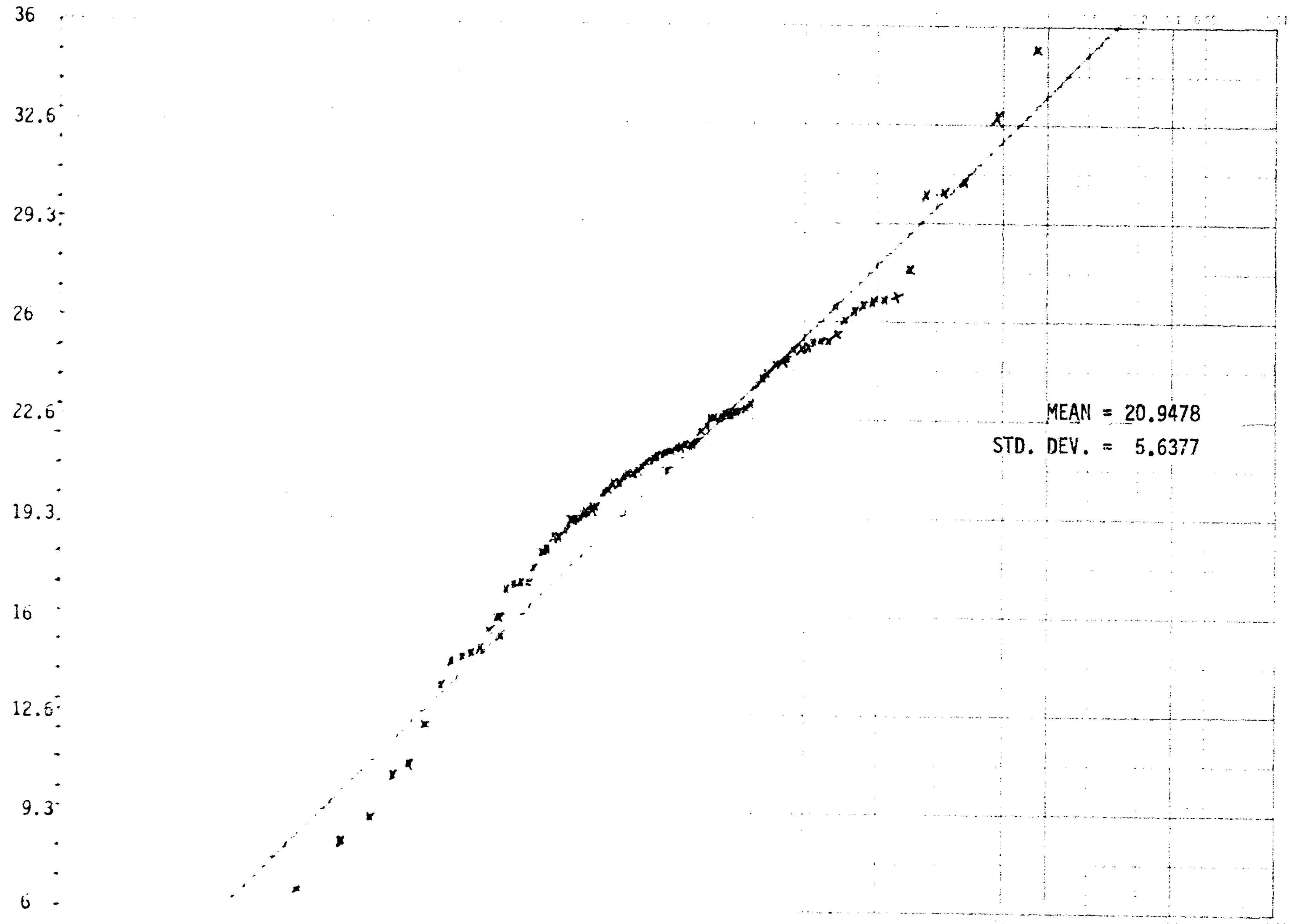

FIGURE 7
RANKED DATA: SUBJECT FOUR

sources other than main effects is divided into two parts. One part, called nonadditivity, corresponds to the linear x linear component of the SCF interaction. The other part, called balance, is what is left. If the nonadditivity component is significantly larger than the balance, it is determined that the three-factor interaction estimated a source of variation different from experimental error. In this case model (i) would be chosen. If model (ii) is chosen, then the triple interaction term, SCF, is considered an estimate of experimental error.

For this experiment, model (ii) is found to be the most appropriate when tested at the 0.95 level of significance. The program to find the appropriate model and the Analysis of Variance table is shown in Appendix C.

The results of this test show the subject to be the most significant factor affecting the data. In an effort to remove this subject effect, the data is standardized for each subject-condition. The standardized subjects are then treated as repetitions. Figure 8 is a sketch of this new model (model 2).

CONDITION (j)	$1 \leq j \leq 2$
FLASH-TIME (k)	$1 \leq k \leq 6$
SUBJECT (i)	$1 \leq i \leq 5$

FIGURE 8

MODEL 2

The data is standardized by finding the mean and standard deviation for each subject-condition and using them in the equation

$\sqrt{n}\,(Y_{jki} - E(Y_{j.i}))/S$. Standardizing the data in this manner does not remove the underlying effect of the control condition, but rather, puts the subjects on the same level.

Once the data is in this form, the model shown in Figure 8 is analyzed as a two factor mixed model. The program for this analysis, along with the corresponding results, is in Appendix C. These results show the condition sum of squares equal to zero. This is due to the fact that the mean of standardized data equals zero.

CHAPTER IV

RESULTS AND DISCUSSION

The results of the analysis of variance, of experimental model one, are tabulated in Table 1. From these results the mathematical equation for model one is derived. Any factor (tabled under the heading SOURCE) whose calculated F value exceeds the value of the F statistic at the .05 level of significance is included in the model shown below:

$$Y_{ijk} = \mu + S_i + F_k + SC_{ij} + CF_{jk} + SCF_{ijk} + \varepsilon_{ijk} \qquad (1)$$

The most significant factor of this model is the subject. For this reason the analysis of model two was deemed advisable.

The results of the analysis of model two, as described in chapter three are tabulated in Table 2. This table shows both the time factor, F, and the condition x time interaction term to be significant at the .05 level of significance.

The resulting mathematical equation for model two is:

$$Y_{jk(i)} = \mu + F_k + CF_{jk} + \varepsilon_{i(jk)} \qquad (2)$$

If the terms involving the subject effect are omitted from model one, the result is model two. However, the two models differ in that model two shows the condition-time interaction to be more significant than the time factor alone, whereas model one expressed the opposite result. There is, however, no real inconsistency between the two models. Model one says that for a particular subject, performance is dictated primarily by the subject's individual ability and secondly, by how long the subject has been operating the tracking task. Model two says that if the effect of a subject's individual ability is mathematically

Table 1

ANOVA Model 1

SOURCE	DF	SS	MS	F	$F^{.05}_{DF,DF}$
S	4	.274545	.068636	1653.646729	2.93
C	1	.000159	.000159	3.830486	4.41
F	5	.258067	.051613	1243.518799	2.77
SC	4	.001382	.000345	8.321779	2.93
SF	20	.017314	.000866	20.857750	2.19
CF	5	.000576	.000115	2.773768	2.77
SCF	18	.000747	.000042		
NONADD	1	.000154	.000154		
BALANCE	17	.000593	.000035		

Table 2

ANOVA Model 2

SOURCE	DF	SS	MS	F	$F^{.05}_{DF,DF}$
C	1	.000000	.000000	.000000	zeros
F	5	56.200233	11.240046	3.032072	2.42
CF	5	65.860474	13.172094	3.553254	2.42
ERROR	48	177.938477	3.707051		

standardized for all subjects, the primary factor influencing performance is the contition-time interaction. It is to be expected, that removing the very large subject effect, will provide a closer look at the effects of the other factors.

Figure 9 shows a graphic representation of the results of model two. For this graph the average standardized subject response for each level of the condition and time factors are plotted as performance versus time for each of the two condition levels. Since on this graph performance is measured by error frequency, higher data values indicate poorer performance.

This graph shows that under the glare condition performance increases with time. The control condition data, as plotted in Figure 9, shows no definitive trend. The comparatively good performance during the middle ten minutes of the control condition, followed by the conversely poor performance during the succeeding ten minute interval, can partly be explained by the subject's response to the questionnaire in Appendix B. Four out of the five subjects complained that the control run seemed far longer than any of the others. It is probable then, that the subjects' ability to keep track of time during a control run decreased, resulting in psychologically but not visually fatigued subjects.

Further insight to the meaning of the data graphed in Figure 9, can be gained by examination of the GSR data. Program three in Appendix C investigates one possible relationship between the subject's performance and his corresponding GSR reading. The proposed relationship says that any increase in performance will have associated with it, a decrease in galvanic skin resistance. Due to the method by which the GSR is measured in this experiment, a decrease in skin resistance is evidenced by an

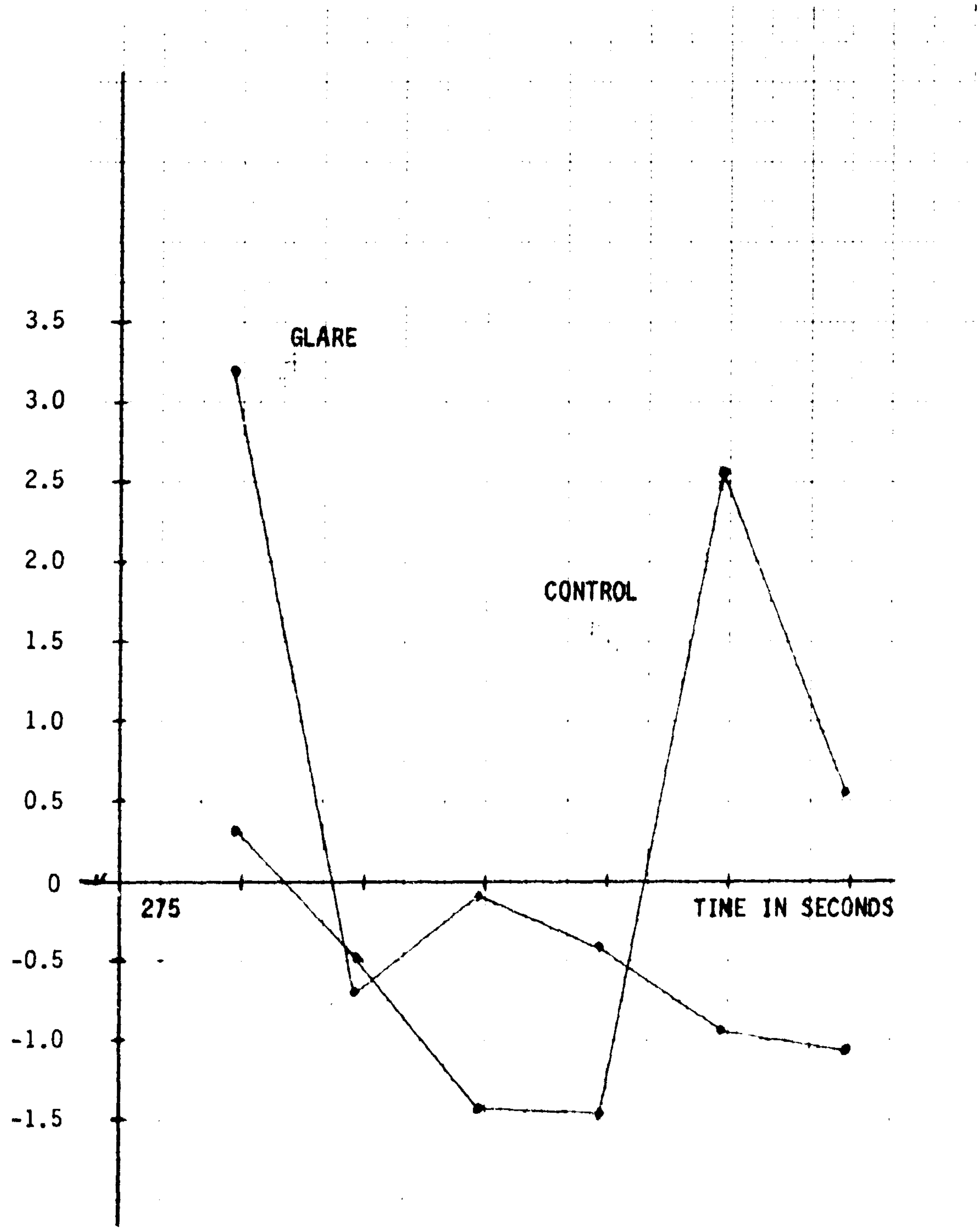

FIGURE 9

AVERAGED STANDARDIZED PERFORMANCE DATA

increase in the GSR reading. The results of program three are shown in Table 3.

Table 3

GSR Versus Performance

	SUBJECT	NN*	M**
Control	1	77	85
	2	43	51
	3	47	57
	4	46	39
	5	96	85
Flash	1	63	65
	2	39	60
	3	56	60
	4	41	50
	5	69	82

* NN = number of points for which GSR follows performance.
**M = number of points for which GSR does not follow performance.

The heading NN in Table 3 represents the number of data points in which the proposed relationship holds, while M is the number of times it does not. For the control runs, NN exceeds M for only two of the five subjects; and for the flash runs, NN never exceeds M.

Program-AVG in Appendix C is an attempt to directly relate the GSR levels to the data, graphed in Figure 9. This program finds the average GSR value for consecutive 275 second intervals, for each subject-

condition level. The GSR values are then standardized and averaged to obtain one data point for each condition-flash-time level. Figure 10 is the resulting plot of this data.

By comparing Figures 9 and 10, it can be seen that in general the trends of the plotted data are the same. This relationship holds for all but one point on the glare data and for all but two points on the control run. For the glare run, the fifth points do not follow the general trend, while for the control run both the third and sixth points disturb the overall pattern.

The questionnaire provides some comments from the subjects concerning the effect of the experiment. Three out of five subjects admitted to feeling fatigued as a consequence of the experiment. However, only two of the five subjects express the glare as bothersome: the other three subjects express the control run as the worst experimental condition. More specifically, these subjects find the glare to be a welcome change of pace.

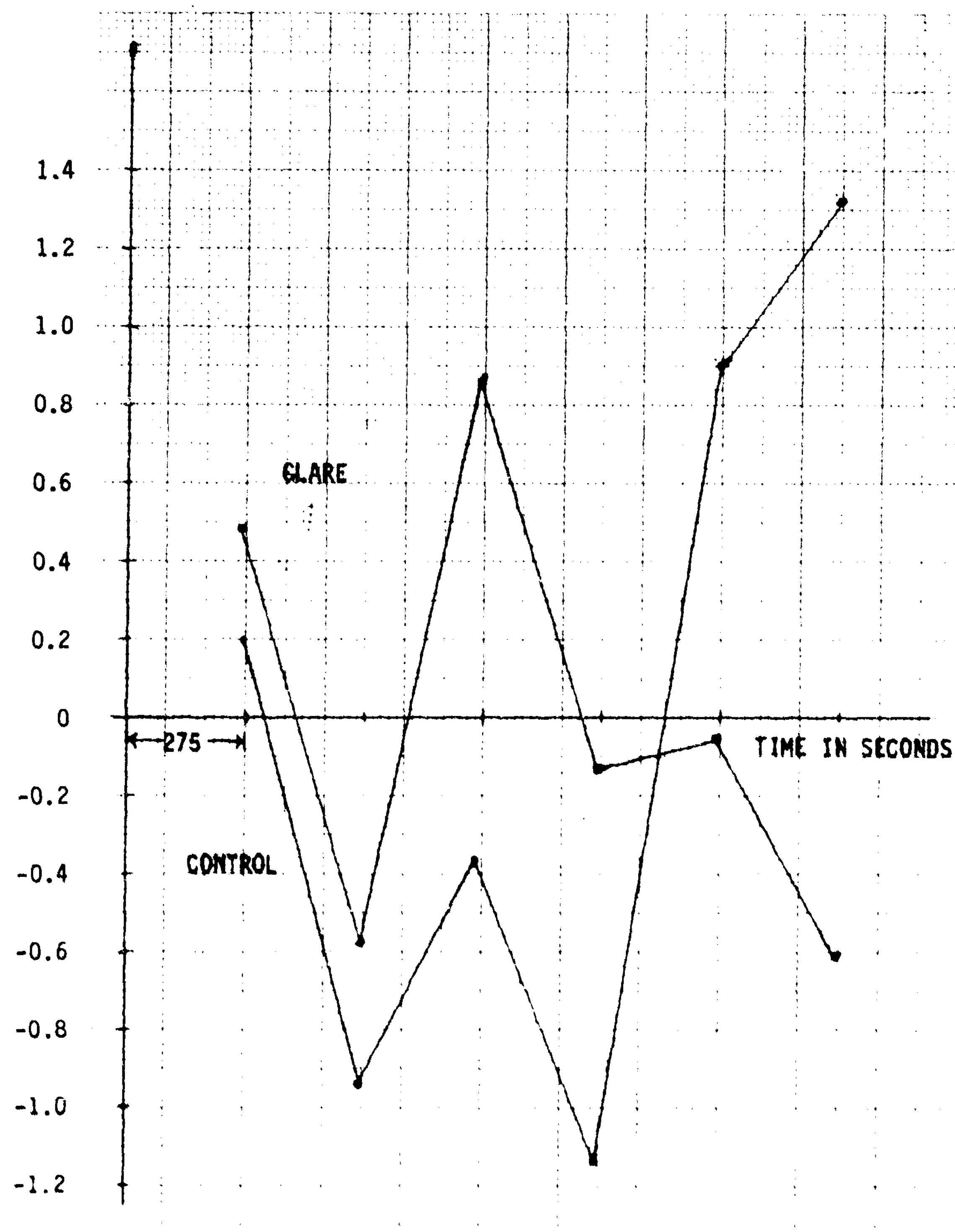

FIGURE 10

AVERAGED STANDARDIZED GSR DATA

CHAPTER V

SUMMARY AND CONCLUSIONS

Five subjects were tested to determine the effects of repeated flashes from a glare source on the performance of a tracking task. The task was given under five different experimental conditions. Analysis of Variance, as well as graphical methods, were applied to the control and white condition runs to determine the effect of the glare.

The Analysis of Variance indicates that both flash-time and the condition-flash-time interaction terms affect subject performance. The graph of the glare data (Figure 9, page 23) shows an overall increase in performance with respect to time. It is probable that the exceptionally poor performance during the first 275 seconds of the glare run is the result of subject anticipation of the first flash. The increasingly better performance during the glare runs suggests that the subjects hold the glare as the condition to be coped with. Consequently, the subjects consistently strive to overcome the obstacle of the flash, during the entire glare run. The result is a good approximation of a learning curve.

The graph of the control data shows a similar increase in performance up to and including the fourth 275 second interval. However, during the fifth time interval there is a drastic decrease in performance, followed by a significant improvement in succeeding time intervals. One explanation of this result is that the subjects view the control run as simply a necessary experimental reference; it represents no challenge and presents no new obstacle for them to surmount. This result is complimentary to the findings of McFarland as noted in Chapter II, page 3 ,

of this report.

A further explanation of the drastic shift in performance after 20 minutes of a control run, can be gained from the inverted U curve. The inverted U curve, as applied to the control run, indicates that after the first 20 minutes the subject's level of arousal has dropped far below the optimal. The subject has relaxed his performance standard. The sudden shift to a lower level of arousal is indicative of a psychologically fatigued subject.

The findings of this paper show the glare to be advantageous in that it tends to hold the subject's level of arousal at or near the optimal.

Future investigations should effectively reverse the titles of the two runs in an effort to indiscretely and falsely convince the subjects that what appears to be a control condition, is actually the condition under investigation. This could most readily be accomplished by employing separate groups for the control and glare runs, using care not to inform the one group of the existence of the other.

The GSR term, as graphed in Figure 10, page 26, suggests that a relationship between performance and galvanic skin resistance does exist. Further, the results of the analysis employed by this investigation show that this relationship is not simplistic in form. Rather, the manner by which galvanic skin resistance can be used to indicate a subject's transient ability to perform, involves more than a discrete GSR value. Further investigation should examine the continuous GSR wave form with respect to a similarly continuous measure of performance.

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GLOSSARY

C: The symbol used for Condition factor. Subscripted by (j) with $j = 1$ representing a control condition; a $j = 2$ representing a glare run.

DF: The symbol used in computer programs for degrees of freedom.

E(Y): The expected value of Y. Estimates μ by the equation $\sum_n Y/n$.

ε: The symbol used for the error term in the statistical analysis of variance.

F: The symbol used for the flash-time factor. Subscripted by (k) with $k = 1$ through 6 corresponding to consecutive 275 second intervals of a run.

MS: The statistical notation for mean square, found by dividing the SS term by its corresponding degrees of freedom.

μ: Symbol used to represent the population mean.

RUN: A generalized term used when referencing the entire thirty minutes of operating the tracking task.

S: The symbol used for Subject. When subscripted by $(1 \leq i \leq 5)$, S refers to a particular subject.

$\not{S}$: Sample standard deviation.

SOURCE: Heading used in analysis of variance to indicate the source of the variation.

SS: Symbol used by analysis of variance programs to represent the sum of squares.

STANDARDIZED: Used in reference to data which has been manipulated by $\sqrt{n}\,(Y - E(Y))/\not{S}$.

APPENDIX

A

```
$JOB
$EX,RTFOR
      DIMENSION A(200,2)
      DIMENSION VAL(10),PT(10),VALUE(200),GSR(200)
      INTEGER HPT
      LOGICAL LOGVAL,SET,RESET
      DATA ICARD,IPRINT,ITV,IKBD/6,16,1,2/
      DATA PT(1),PT(2),PT(3),PT(4),PT(5),PT(6)/4HP042,
     14HP043,4HP063,4HP082,4HP100,4HP102/
      DATA PT(7),PT(8)/4HP004,4HP009/
      DATA PT(9)/4HP040/
      DATA VAL(1),VAL(2),VAL(3),VAL(4),VAL(5),VAL(6)/.9999,.5,
     1.5,.01,.9999 ,.25/
      DATA VAL(7),VAL(8)/.75,.75/
      DATA VAL(9) /.0300/
      DATA PT(10)/4HP106/
      DATA VAL(10)/.0010/
      DATA SET,RESET/.TRUE.,.FALSE./
      HPT=40
      CALL QSHYIN(IERR,680)
      CALL QSDLYR(2.,IERR)
C     INSTRUCTION CARDS
  116 CONTINUE
      TYPE115
  115 FORMAT(33H    INSTRUCTIONS                 )
      TYPE 215
  215 FORMAT(41H SET PUSH BUTTON 1 ON, PUSH BUTTON 4 OFF )
      TYPE 315
  315 FORMAT(30H PLACE IN 10**6. AND RUN MODE )
      TYPE 415
  415 FORMAT(35HTURN ON SCOPE AND SELECT CROSSPLOT )
      TYPE 515
  515 FORMAT(48HPLACE COUNTERS AND MONOSTABLES AT DESIRED VALUE )
      TYPE 525
  525 FORMAT(31H PLACE INTO NORMAL AND SECONDS )
      TYPE 615
  615 FORMAT(50H WHEN YOU WISH TO STOP RUN PLACE PUSH BUTTON 4 ON )
      TYPE 715
  715 FORMAT(32H IF YOU HAVE DONE THIS TYPE A 1 )
      READ(IKBD, 40)JAA
      IF(JAA-1)116,216,116
  216 CONTINUE
      DO 10 I=1,10
      CALL QWPR(PT(I),VAL(I),IERR)
      CALL QSDLYR(300.,IERR)
   10 CONTINUE
      CALL QSIC(IERR)
      CALL QSDLYR(13.,IERR)
      CALL QWCLL(1,SET,IERR)
      CALL QSDLYR(2.,IERR)
C     TO IMPUT THE NUMBER OF SUBJECTS PREVIOUSLY TESTED
      CALL QSOP(IERR)
      CALL QSDLYR(13.,IERR)
      WRITE(ITV,11)
   11 FORMAT (46HENTER THE NUMBER OF SUBJECTS PREVIOUSLY TESTED)
      READ(IKBD,12)ISPT
   12 FORMAT(I3)
```

```
      WRITE(ITV,13)
   13 FORMAT (38HSET PUSH BUTTONS TO ZERO THEN TYPE  1 )
   14 READ(IKBD,40)IA
   40 FORMAT(I1)
      IF (IA-1)12,50,50
   50 CALL QWCLL(1,RESET,IERR)
      CALL QSDLYR(4.,IERR)
      CALL QWCLL(1,SET,IERR)
      CALL QSDLYR(2.,IERR)
      C=0
      J=0
      ISPT=ISPT+1
   15 CALL QRCPL(99,LOGVAL,IERR)
      CALL QSDLYR(2.,IERR)
      IF(.NOT.LOGVAL)GO TO 15
      CALL QRBADR(VALUC,6,1,IERR)
      CALL QRBADR(GSRE,7,1,IERR)
      TYPE 1,J,VALUC,GSRE
    1 FORMAT(I3,G18.6,G18.6)
      CALL QSDLYR(2.,IERR)
      CALL QWCLL(1,RESET,IERR)
      CALL QSDLYR(4.,IERR)
      CALL QWCLL(1,SET,IERR)
      CALL QSDLYR(2.,IERR)
      C=C+1.
      J=J+1
      VALUE(J)=VALUC/VAL(4)
      GSR(J)=GSRE
      IF(J-200)911,911,912
  912 TYPE 913
  913 FORMAT(40H EXCEEDED J VALUE LIMIT                       )
C     TO STOP AFTER 30 MINUTES
  911 CALL QRSLL(J,LOGVAL,IERR)
      CALL QSDLYR(2.,IERR)
      CALL QRSLL(J,LOGVAL,IERR)
      CALL QSDLYR(2.,IERR)
      IF(.NOT.LOGVAL)GO TO 15
   20 CALL QSH(IERR)
      CALL QRBADR (BT,3,1,IERR)
      CALL QSDLYR(13.,IERR)
      WRITE(ITV,9)
    9 FORMAT (99HIF YOU WISH A PRINTOUT OF THE VALUES OF THE
     1ARRAY THEN TYPE 1 ')
    7 READ(IKBD,40) IC
      IF(IC-1)123,6,123
C     BEGIN COMPILATION OF DATA
    6 WRITE(ITV,16)
   16 FORMAT (42HCOMPILATION OF DATA AND PRINTOUT BEGINNING)
      WRITE(IPRINT,26)ISPT
   26 FORMAT (1H1,20X,43HPRINTOUT OF ARRAY VALUES FOR SUBJECT NUMBER,
     1I5)
      WRITE(HPT,51) J
   51 FORMAT(I3)
      DO 17 I=1,J
      TB=BT/VAL(10)
      WRITE(HPT,52) I,VALUE(I),GSR(I)
   52 FORMAT(I3,F10.3,F10.3)
      WRITE(IPRINT,18)I,VALUE(I),GSR(I),TB
   18 FORMAT(20X,2HJ=,I3,20X,F10.3,F20.3,F10.3)
   17 CONTINUE
```

```
      JQ=1
      MMM=-9
      I=0
      DO 1000 JJJ=1,20
      MMM=MMM+10
      I=I+10
      IF (I-J)1222,1222,1111
 1222 CONTINUE
      CALL SQPG(I,GSR,JQ,10.,MMM)
 1000 CALL SQPM(I,VALUE,JQ,10.,MMM)
 1111 I=J
      CALL SQPG(I,GSR,JQ,C,1)
      CALL SQPM(I,VALUE,JQ,C,1)
  123 CONTINUE
C     TO PLOT ON CRT
      WRITE(ITV,19)
   19 FORMAT(53HDO YOU WISH THE VALUES OR THE ARRAY TO BE PLOTTED ,
     1/,20HIF YES THEN TYPE   2 )
   21 READ(IKBD,4)I8
      IF(I8-2)122,24,122
   24 CONTINUE
C     PLOT PROGRAM
      DO 69 I=1,J
      A(I,1)=I
      A(I,2)=VALUE(I)
   69 CONTINUE
      CALL APLOT(A,200,1,J)
  122 CONTINUE
C     TO STOP OR HOLD AT THE END OF A RUN
      WRITE(ITV,101)
  101 FORMAT( 45HTYPE   1     IF YOU WISH TO STOP THE EXPERIMENT,
     1 / ,37H2  IF YOU WISH TO START A NEW SUBJECT,
     1  / ,45H  3 IF YOU WISH TO HOLD WAITING A NEW SUBJECT)
  105 READ(IKBD,102)JA
  102 FORMAT(I1)
      GO TO(100,10,10),JA
C     SHUT DOWN SEQUENCE
  100 CONTINUE
      END
      SUBROUTINE APLOT(A,N,NPLOT,NPNT)
      DIMENSION A(1)
      CALL BEGIN(9600,1)
      CALL ERASE
      CALL VECTOR
      XMAX=A(1)
      XMIN=A(1)
      DO 30 I=1,NPNT
      IF(A(I).LT.XMIN)XMIN=A(I)
      IF(A(I).GT.XMAX)XMAX=A(I)
30    CONTINUE
      NDX=N+1
      YMIN=A(NDX)
      YMAX=YMIN
      DO 90 I1=1,NPLOT
      DO 80 I2=1,NPNT
      NDX=I1*N+I2
      IF(A(NDX).LT.YMIN)YMIN=A(NDX)
```

```
      IF(A(NDX).GT.YMAX)YMAX=A(NDX)
 80   CONTINUE
 90   CONTINUE
      XFACT=800./(XMAX-XMIN)
      YFACT=500./(YMAX-YMIN)
      XORG=(1023.-800.)/2.
      IF(XMIN.LT.0.)XORG=223.-800.*XMIN/(XMAX-XMIN)
      YORG=140.
      IF(YMIN.LT.0.)YORG=140.-500.*YMIN/(YMAX-YMIN)
      CALL SCALE(XFACT,YFACT,XORG,YORG)
      XLOW=XMIN
      IF(XMIN.GE.0.)XLOW=0.
      YLOW=YMIN
      IF(YMIN.GE.0.)YLOW=0.
      XLNG=(XMAX-XMIN)
      YLNG=(YMAX-YMIN)
      XTIC=XLNG/10.
      YTIC=YLNG/10.
      MARKX=1
      MARKY=1
      CALL AXIS(XLOW,YLOW,XLNG,YLNG,XTIC,YTIC,MARKX,MARKY)
      DO 1000 I2=1,NPLOT
      CALL VECTOR
      DO 2000 I1=1,NPNT
      IF(I1-1)10,20,10
 20   IPEN=0
      MARK=0.
      GO TO 40
 10   IPEN=1
 40   CONTINUE
      NDX=I2*N+I1
      X=A(I1)
      IF(XMIN.GE.0.)X=A(I1)-XMIN
      Y=A(NDX)
      IF(YMIN.GE.0.)Y=A(NDX)-YMIN
      CALL TPLOT(X,Y,IPEN,MARK)
 2000 CONTINUE
      CALL TPAUSE
 1000 CONTINUE
      RETURN
      END
      SUBROUTINE SQPM(I,VALUE,JQ,C,MMM)
      DIMENSION VALUE(1),JQ(1),S(100),AMEAN(100),B(100)
      DIMENSION FFF(100)
      ASUM=0.0
      SUM=0.0
      DO 9122 K=MMM,I
      B(K)=VALUE(K)**2
      SUM=SUM+B(K)
      ASUM=ASUM+VALUE(K)
 9122 CONTINUE
      S(JQ)=SQRT((SUM-(ASUM**2)*(1./C))*(1./(C-1.)))
      AMEAN(JQ)=ASUM/C
      FFF(JQ)=(S(JQ)**2/AMEAN(JQ))*100.
      WRITE(16,815)C,S(JQ),AMEAN(JQ),FFF(JQ)
  815 FORMAT(F20.0,29HSAMPLE STANDARD DEVIATION IS ,G18.6,
     114HSAMPLE MEAN IS ,G18.6,11H FFACT IS ,F8.4)
```

```
      RETURN
      END
      SUBROUTINE SOPG(I,VALUE,JQ,C,MMM)
      DIMENSION VALUE(1),JQ(1),S(100),AMEAN(100),B(100)
      DIMENSION FFF(100)
      ASUM=0.0
      SUM=0.0
      DO 9122 K=MMM,1
      B(K)=VALUE(K)**2
      SUM=SUM+B(K)
      ASUM=ASUM+VALUE(K)
 9122 CONTINUE
      S(JQ)=SQRT(SUM-(ASUM**2)*(1./C))*(1./(C-1.))
      AMEAN(JQ)=ASUM/C
      FFF(JQ)=(S(JQ)**2/AMEAN(JQ))*100.
      WRITE(16,815)C,S(JQ),AMEAN(JQ),FFF(JQ)
  815 FORMAT(F15.0,5HGSR   ,29HSAMPLE STANDARD DEVIATION IS ,G18.6,
     114HSAMPLE MEAN IS ,G18.6,11HWINFACT IS ,F8.4)
      RETURN
      END

$EX,RTCIG
IN,*
IN,RTPLOT,.DK3
IN,RTHRTL,.DK3
IN,RTRTL,.DK3
FOR
UN
END
$AS,H1,50
$AS,T1,.CU
```

PRINTOUT OF ARRAY VALUES FOR SUBJECT NUMBER 3

J= 1	7.784	.175	3.418
J= 2	17.316	.170	3.418
J= 3	12.823	.171	3.418
J= 4	17.023	.166	3.418
J= 5	17.236	.169	3.418
J= 6	30.029	.160	3.418
J= 7	21.826	.154	3.418
J= 8	15.967	.195	3.418
J= 9	17.706	.156	3.418
J= 10	14.502	.162	3.418
J= 11	13.409	.167	3.418
J= 12	11.963	.177	3.418
J= 13	21.729	.173	3.418
J= 14	15.088	.188	3.418
J= 15	10.870	.165	3.418
J= 16	17.920	.152	3.418
J= 17	24.268	.167	3.418
J= 18	27.686	.165	3.418
J= 19	11.066	.153	3.418
J= 20	14.191	.165	3.418
J= 21	15.656	.152	3.418
J= 22	17.120	.187	3.418
J= 23	19.385	.151	3.418
J= 24	15.869	.172	3.418
J= 25	21.533	.172	3.418
J= 26	17.218	.170	3.418
J= 27	13.409	.182	3.418
J= 28	17.120	.187	3.418
J= 29	16.357	.155	3.418
J= 30	18.311	.160	3.418
J= 31	20.441	.152	3.418
J= 32	13.312	.148	3.418
J= 33	6.299	.159	3.418
J= 34	19.073	.185	3.418
J= 35	23.077	.175	3.418
J= 36	14.679	.195	3.418
J= 37	16.748	.177	3.418
J= 38	20.068	.179	3.418
J= 39	20.148	.168	3.418
J= 40	17.511	.160	3.418
J= 41	26.105	.172	3.418
J= 42	19.482	.151	3.418
J= 43	21.710	.154	3.418
J= 44	19.775	.166	3.418
J= 45	17.223	.167	3.418
J= 46	22.412	.171	3.418
J= 47	8.624	.172	3.418
J= 48	19.464	.215	3.418
J= 49	20.831	.161	3.418
J= 50	20.264	.150	3.418
J= 51	14.893	.151	3.418
J= 52	25.128	.170	3.418
J= 53	15.656	.203	3.418
J= 54	18.408	.190	3.418
J= 55	20.530	.150	3.418
J= 56	19.171	.152	3.418
J= 57	11.084	.153	3.418
J= 58	14.014	.160	3.418
J= 59	17.334	.151	3.418
J= 60	22.217	.147	3.418
J= 61	21.124	.175	3.418
J= 62	17.902	.181	3.418

J= 63	16.730	.174	3.418
J= 64	20.459	.159	3.418
J= 65	17.725	.157	3.418
J= 66	12.451	.162	3.418
J= 67	16.827	.152	3.418
J= 68	17.413	.188	3.418
J= 69	24.835	.163	3.418
J= 70	20.538	.163	3.418
J= 71	13.037	.183	3.418
J= 72	6.163	.186	3.418
J= 73	19.073	.221	3.418
J= 74	14.679	.175	3.418
J= 75	19.482	.171	3.418
J= 76	12.451	.186	3.418
J= 77	27.979	.165	3.418
J= 78	17.627	.181	3.418
J= 79	15.827	.161	3.418
J= 80	21.045	.163	3.418
J= 81	19.287	.210	3.418
J= 82	16.658	.188	3.418
J= 83	12.238	.185	3.418
J= 84	9.619	.176	3.418
J= 85	15.753	.182	3.418
J= 86	13.232	.190	3.418
J= 87	20.441	.177	3.418
J= 88	14.6[illegible]	.189	3.418
J= 89	19.[illegible]	.203	3.418
J= 90	13.[illegible]7	.167	3.418
J= 91	22.9[illegible]	.163	3.418
J= 92	12.238	.155	3.418
J= 93	15.576	.174	3.418
J= 94	16.[illegible]4	.203	3.418
J= 95	20.[illegible]	.165	3.418
J= 96	12.14[illegible]	.160	3.418
J= 97	9.521	.157	3.418
J= 98	18.[illegible]	.161	3.418
J= 99	18.[illegible]	.18[illegible]	3.418
J=100	19.385	.167	3.418
J=101	11.[illegible]8	.167	3.418
J=102	17.92[illegible]	.176	3.418
J=103	13.232	.194	3.418
J=104	1[illegible]	.175	3.418
J=105	25.[illegible]	.219	3.418

```
1 .75S    SAMPLE STANDARD DEVIATION IS    .302221E-02SAMPLE MEAN IS    .167914    WINFACT IS    .0092
     1 .SAMPLE STANDARD DEVIATION IS    1.935[illegible]     SAMPLE MEAN IS    17.2192    WINFACT IS    21.7449
1 .[illegible] SAMPLE STANDARD DEVIATION IS    .356322E-02SAMPLE MEAN IS    .167151    WINFACT IS    .0076
     1 .SAMPLE STANDARD DEVIATION IS    1.96411      SAMPLE MEAN IS    16.8188    WINFACT IS    22.9369
1 .[illegible] SAMPLE STANDARD DEVIATION IS    .463238E-02SAMPLE MEAN IS    .168799    WINFACT IS    .0127
     1 .SAMPLE STANDARD DEVIATION IS    .737275      SAMPLE MEAN IS    17.1979    WINFACT IS    3.1607
1 .[illegible] SAMPLE STANDARD DEVIATION IS    .502275E-02SAMPLE MEAN IS    .169775    WINFACT IS    .0149
     1 .SAMPLE STANDARD DEVIATION IS    1.5940[illegible]     SAMPLE MEAN IS    17.1356    WINFACT IS    14.8446
1 .[illegible] SAMPLE STANDARD DEVIATION IS    .62610[illegible]E-02SAMPLE MEAN IS    .167914    WINFACT IS    .0234
     1 .SAMPLE STANDARD DEVIATION IS    1.50633      SAMPLE MEAN IS    19.5691    WINFACT IS    11.5949
1 .[illegible] SAMPLE STANDARD DEVIATION IS    .63899[illegible]E-02SAMPLE MEAN IS    .162585    WINFACT IS    .0251
     1 .SAMPLE STANDARD DEVIATION IS    1.38021      SAMPLE MEAN IS    17.8442    WINFACT IS    10.7688
1 .[illegible] SAMPLE STANDARD DEVIATION IS    .30013[illegible]E-02SAMPLE MEAN IS    .167230    WINFACT IS    .0091
     1 .SAMPLE STANDARD DEVIATION IS    1.10873      SAMPLE MEAN IS    18.6005    WINFACT IS    6.6088
1 .[illegible] SAMPLE STANDARD DEVIATION IS    .578453E-02SAMPLE MEAN IS    .179364    WINFACT IS    .0107
     1 .SAMPLE STANDARD DEVIATION IS    1.94462      SAMPLE MEAN IS    16.8384    WINFACT IS    22.4579
1 .[illegible] SAMPLE STANDARD DEVIATION IS    .423845E-02SAMPLE MEAN IS    .186841    WINFACT IS    .0096
     1 .SAMPLE STANDARD DEVIATION IS    1.178[illegible]     SAMPLE MEAN IS    15.4242    WINFACT IS    8.9962
1 .[illegible] SAMPLE STANDARD DEVIATION IS    .484188E-02SAMPLE MEAN IS    .168423    WINFACT IS    .0139
     1 .SAMPLE STANDARD DEVIATION IS    1.427[illegible]     SAMPLE MEAN IS    16.8188    WINFACT IS    12.1174


1 5.[illegible] SAMPLE STANDARD DEVIATION IS    .158270E-02SAMPLE MEAN IS    .171306    WINFACT IS    .0015
    1 5.SAMPLE STANDARD DEVIATION IS    .447[illegible]87      SAMPLE MEAN IS    17.2687    WINFACT IS    1.1575
```

A P P E N D I X

B

```
      DIMENSION FREQ(20)
      DIMENSION VALUE(200),J(200),GSR(200),UBO(3)
      DIMENSION PCT(20)
      LOGICAL SENSW
      INTEGER HPT
      COMMON MX,MY
      DATA UBO/3*0./
      NU=0
      MX=16
      MY=6
      HPT=40
      IPN=16
    2 READ(HPT,9) N
      WRITE(IPN,990)
      DO 11 II=1,N
      READ(HPT,8) J(II),VALUE(II),GSR(II)
   11 CONTINUE
      C=0.
      R=1.
      DO 10 I=1,N
      C=C+1.
      DO 10 K=I,N
      IF (VALUE(I)-VALUE(K))1,10,10
    1 W=VALUE(K)
      VALUE(K)=VALUE(I)
      VALUE(I)=W
   10 CONTINUE
      DO 20 II=1,N
      R=R+1.
      AI=(C+1.-R)/(C+1.)
   20 WRITE(IPN,12) II,VALUE(II),AI
      XMEAN=SMEAN(VALUE,N)
      XSTD=SVAR(VALUE,N,1,XMEAN)
      XSTD=SQRT(XSTD)
      WRITE(IPN,13) XMEAN,XSTD
      UBO(2)=15
      CALL TAB1(VALUE,VALUE,1,UBO,FREQ,PCT,STATS,N,1)
      NU=NU+1
      WRITE(IPN,999)
      IU=UBO(2)
      CALL HIST(NU,FREQ,IU)
   99 IF(.NOT.SENSW(1)) GOTO 99
      IF(SENSW(3)) GOTO 2
      CALL EXIT
  999 FORMAT(1H1)
   13 FORMAT(20X,F10.4,10X,F10.4)
   12 FORMAT(20X,I3,10X,F10.4,10X,F10.3)
    9 FORMAT (I3)
    8 FORMAT(I3,2(F10.3))
      END
```

1	26.8860	.994
2	21.5150	.988
3	20.8310	.982
4	20.1480	.976
5	19.1890	.970
6	18.9940	.963
7	18.7990	.957
8	17.9200	.951
9	17.6270	.945
10	17.2360	.939
11	17.1390	.933
12	17.0410	.927
13	17.0410	.921
14	16.6500	.915
15	16.6500	.909
16	16.3570	.902
17	16.2410	.896
18	16.0460	.890
19	15.9670	.884
20	15.7530	.878
21	15.5760	.872
22	15.5580	.866
23	15.4790	.860
24	14.7950	.854
25	14.7770	.848
26	14.6790	.841
27	14.4840	.835
28	14.4840	.829
29	14.4040	.823
30	14.2090	.817
31	14.1910	.811
32	13.9950	.805
33	13.8980	.799
34	13.8000	.793
35	13.6230	.787
36	13.6230	.780
37	13.6230	.774
38	13.4280	.768
39	13.4090	.762
40	13.3300	.756
41	13.3300	.750
42	13.2140	.744
43	13.0370	.738
44	13.0370	.732
45	13.0370	.726
46	12.8420	.720
47	12.7440	.713
48	12.7440	.707
49	12.7260	.701
50	12.7260	.695
51	12.6460	.689
52	12.6280	.683
53	12.4510	.677
54	12.4510	.671
55	12.2560	.665
56	12.2560	.65[illegible]
57	12.2380	.652
58	12.158[illegible]	.64[illegible]
59	12.158[illegible]	.64[illegible]
60	12.143[illegible]	.634
61	12.14[illegible]	.62[illegible]
62	12.14[illegible]	.622

63	12.0610	.616
64	12.0610	.610
65	12.0610	.604
66	12.0420	.598
67	11.9630	.591
68	11.9630	.585
69	11.9450	.579
70	11.8650	.573
71	11.8470	.567
72	11.8470	.561
73	11.7680	.555
74	11.7680	.549
75	11.7490	.543
76	11.7490	.537
77	11.6520	.530
78	11.6520	.524
79	11.5720	.518
80	11.5540	.512
81	11.4750	.506
82	11.4560	.500
83	11.4560	.494
84	11.3590	.488
85	11.2790	.482
86	11.2610	.476
87	11.0660	.470
88	10.9680	.463
89	10.8700	.457
90	10.7910	.451
91	10.7730	.445
92	10.6930	.439
93	10.6930	.433
94	10.6930	.427
95	10.6750	.421
96	10.5960	.415
97	10.5770	.409
98	10.4980	.402
99	10.4800	.396
100	10.4000	.390
101	10.2050	.384
102	9.9120	.378
103	9.9120	.372
104	9.7170	.366
105	9.7170	.360
106	9.7170	.354
107	9.7170	.348
108	9.6980	.341
109	9.6980	.335
110	9.6010	.329
111	9.4260	.323
112	9.4060	.317
113	9.4260	.311
114	9.3260	.305
115	9.3260	.299
116	9.2190	.293
117	9.1310	.287
118	9.1130	.281
119	9.0330	.274
120	9.0330	.268
121	9.0330	.262
122	8.9170	.256
123	8.6430	.250
124	8.6240	.244
125	8.5450	.238
126	8.4470	.232

127	8.4470	.226
128	8.4290	.220
129	8.4290	.213
130	8.2340	.207
131	8.2340	.201
132	8.1360	.195
133	8.0570	.189
134	8.0570	.183
135	8.0380	.177
136	8.0380	.171
137	8.0380	.165
138	8.0380	.159
139	7.9410	.152
140	7.9410	.146
141	7.8610	.140
142	7.8430	.134
143	7.7450	.128
144	7.6660	.122
145	7.3730	.116
146	7.3730	.110
147	7.3550	.104
148	7.3550	.098
149	7.2570	.091
150	7.1590	.085
151	7.0860	.079
152	6.9640	.073
153	6.6890	.067
154	6.5730	.061
155	6.2990	.055
156	6.2810	.049
157	6.1040	.043
158	6.0060	.037
159	5.9880	.030
160	3.2530	.024
161	2.6670	.018
162	2.1790	.012
163	1.9040	.006
11.3938	3.7151	

HISTOGRAM 1

FREQUENCY	0	4	0	16	33	30	43	14	14	5	2	1	0	0	1
INTERVAL CLASS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

1	32.6660	.990
2	31.3780	.979
3	30.1090	.969
4	29.7180	.958
5	26.9040	.948
6	26.4160	.937
7	26.0070	.927
8	25.7140	.917
9	25.5190	.906
10	25.4390	.896
11	25.2440	.885
12	24.1700	.875
13	23.9750	.865
14	23.6820	.854
15	23.2910	.844
16	22.8820	.833
17	22.8030	.823
18	22.5890	.812
19	22.3140	.802
20	22.2170	.792
21	21.8260	.781
22	21.8260	.771
23	21.8260	.760
24	21.8260	.750
25	21.7290	.740
26	21.5330	.729
27	21.3380	.719
28	21.2220	.708
29	21.1430	.698
30	21.0450	.687
31	20.9290	.677
32	20.6540	.667
33	20.6360	.656
34	20.5380	.646
35	20.4410	.635
36	20.4410	.625
37	20.2640	.615
38	20.2450	.604
39	20.1560	.594
40	20.1480	.583
41	20.0680	.573
42	19.9710	.562
43	19.5620	.552
44	19.4640	.542
45	19.0730	.531
46	18.8960	.521
47	18.7990	.510
48	18.7810	.500
49	18.7010	.490
50	18.7010	.479
51	18.4080	.469
52	18.3000	.458
53	18.2130	.448
54	18.0970	.437
55	18.0970	.427
56	17.9200	.417
57	17.9020	.406
58	17.7060	.396
59	17.6090	.385
60	17.5290	.375
61	17.5290	.365
62	17.2180	.354

63	16.9430	.344
64	16.9250	.333
65	16.5340	.323
66	16.5340	.312
67	16.3570	.302
68	16.3390	.292
69	16.2600	.281
70	16.1620	.271
71	16.0640	.260
72	15.9480	.250
73	15.8690	.240
74	15.5760	.229
75	15.5760	.219
76	15.3630	.208
77	15.1670	.198
78	14.6000	.187
79	14.0140	.177
80	13.5250	.167
81	13.2320	.156
82	13.2320	.146
83	13.1350	.135
84	13.0370	.125
85	12.7440	.115
86	12.6280	.104
87	12.1430	.094
88	12.0610	.083
89	12.0420	.073
90	11.9630	.062
91	11.8470	.052
92	11.7680	.042
93	11.3770	.031
94	10.7730	.021
95	6.8660	.010
18.9689	4.7976	

HISTOGRAM 2

```
FREQUENCY    0   1   1   9   7  13  16  17  14   6   6   1   2   1   1
----------------------------------------------------------------------
      17                                 *
      16                             *   *
      15                             *   *
      14                             *   *   *
      13                         *   *   *   *
      12                         *   *   *   *
      11                         *   *   *   *
      10                         *   *   *   *
       9                 *       *   *   *   *
       8                 *       *   *   *   *
       7                 *   *   *   *   *   *
       6                 *   *   *   *   *   *   *   *
       5                 *   *   *   *   *   *   *   *
       4                 *   *   *   *   *   *   *   *
       3                 *   *   *   *   *   *   *   *
       2                 *   *   *   *   *   *   *   *       *
       1         *   *   *   *   *   *   *   *   *   *   *   *   *   *
----------------------------------------------------------------------

INTERVAL     1   2   3   4   5   6   7   8   9  10  11  12  13  14  15
CLASS
```

1	30.0290	.991
2	27.9790	.981
3	27.6860	.972
4	26.1050	.962
5	25.3230	.953
6	25.1280	.943
7	24.8350	.934
8	24.2680	.925
9	23.0770	.915
10	22.9800	.906
11	22.4120	.896
12	22.2170	.887
13	21.8260	.877
14	21.7290	.868
15	21.7100	.858
16	21.5330	.849
17	21.1240	.840
18	21.0450	.830
19	20.8310	.821
20	20.5380	.811
21	20.5380	.802
22	20.4590	.792
23	20.4410	.783
24	20.4410	.774
25	20.3430	.764
26	20.2640	.755
27	20.1480	.745
28	20.0680	.736
29	19.7750	.726
30	19.4820	.717
31	19.4820	.708
32	19.4640	.698
33	19.3850	.689
34	19.3850	.679
35	19.3850	.670
36	19.2870	.660
37	19.1710	.651
38	19.0730	.642
39	19.0730	.632
40	18.9940	.623
41	18.6040	.613
42	18.4080	.604
43	18.4080	.594
44	18.3110	.585
45	17.9200	.575
46	17.9200	.566
47	17.9020	.557
48	17.7250	.547
49	17.7060	.538
50	17.6270	.528
51	17.5110	.519
52	17.4130	.509
53	17.3340	.500
54	17.3160	.491
55	17.2360	.481
56	17.2180	.472
57	17.1200	.462
58	17.1200	.453
59	17.0230	.443
60	17.0230	.434
61	16.8270	.425
62	16.8270	.415

63	16.7480	.406
64	16.7300	.396
65	16.6500	.387
66	16.3570	.377
67	15.9670	.368
68	15.8690	.358
69	15.7530	.349
70	15.6560	.340
71	15.6560	.330
72	15.5760	.321
73	15.0880	.311
74	14.8930	.302
75	14.6790	.292
76	14.6790	.283
77	14.6000	.274
78	14.5020	.264
79	14.1910	.255
80	14.0140	.245
81	13.4090	.236
82	13.4090	.226
83	13.3120	.217
84	13.2320	.208
85	13.2320	.198
86	13.0370	.189
87	13.0370	.179
88	12.8230	.170
89	12.4510	.160
90	12.4510	.151
91	12.2380	.142
92	12.2380	.132
93	12.1400	.123
94	11.9630	.113
95	11.0840	.104
96	11.0840	.094
97	11.0660	.085
98	10.9860	.075
99	10.8700	.066
100	9.6190	.057
101	9.5210	.047
102	8.6240	.038
103	7.7640	.028
104	6.2990	.019
105	6.1830	.009

17.2687 4.5595

HISTOGRAM 3

```
FREQUENCY    0    3    3    5   14    8   16   17   21    8    3    4    2    0    1
---------------------------------------------------------------------------------------
       21                                            *
       20                                            *
       19                                            *
       18                                            *
       17                                       *    *
       16                                  *    *    *
       15                                  *    *    *
       14                        *         *    *    *
       13                        *         *    *    *
       12                        *         *    *    *
       11                        *         *    *    *
       10                        *         *    *    *
        9                        *         *    *    *
        8                        *    *    *    *    *    *
        7                        *    *    *    *    *    *
        6                        *    *    *    *    *    *
        5                   *    *    *    *    *    *    *
        4                   *    *    *    *    *    *    *         *
        3         *    *    *    *    *    *    *    *    *    *    *
        2         *    *    *    *    *    *    *    *    *    *    *    *
        1         *    *    *    *    *    *    *    *    *    *    *    *         *
---------------------------------------------------------------------------------------

INTERVAL     1    2    3    4    5    6    7    8    9   10   11   12   13   14   15
CLASS
$JOB
$AS,H1,50
$EX,*
```

1	35.2840	.989
2	32.9410	.977
3	30.7920	.966
4	30.4200	.954
5	30.4200	.943
6	27.7650	.931
7	26.8070	.920
8	26.7090	.908
9	26.6910	.897
10	26.5140	.885
11	26.3980	.874
12	26.1050	.862
13	25.6350	.851
14	25.4390	.839
15	25.4210	.828
16	25.3230	.816
17	25.2440	.805
18	25.2260	.793
19	25.1280	.782
20	24.7560	.770
21	24.6580	.759
22	24.6400	.747
23	24.2490	.736
24	24.1700	.724
25	23.9750	.713
26	23.1750	.701
27	23.0770	.690
28	22.9800	.678
29	22.9000	.667
30	22.9000	.655
31	22.8030	.644
32	22.7050	.632
33	22.7050	.621
34	22.7050	.610
35	22.4910	.598
36	22.2960	.586
37	21.9060	.575
38	21.8260	.563
39	21.8260	.552
40	21.7290	.540
41	21.7100	.529
42	21.6310	.517
43	21.6310	.506
44	21.6130	.494
45	21.4170	.483
46	21.3380	.471
47	21.2400	.460
48	21.0270	.448
49	20.9470	.437
50	20.8310	.425
51	20.8310	.414
52	20.7520	.402
53	20.4590	.391
54	20.4590	.379
55	20.2450	.368
56	19.8730	.356
57	19.6590	.345
58	19.4820	.333
59	19.4820	.322
60	19.3850	.310
61	19.2870	.299
62	19.2690	.287
63	18.8780	.276

64	18.7010	.264
65	18.6830	.253
66	18.1950	.241
67	18.1150	.230
68	17.6270	.218
69	17.1390	.207
70	17.1390	.195
71	17.1200	.184
72	16.9250	.172
73	15.8690	.161
74	15.4600	.149
75	14.8740	.138
76	14.6970	.126
77	14.6000	.115
78	14.3860	.103
79	13.6050	.092
80	12.2560	.080
81	10.8890	.069
82	10.4800	.057
83	9.0150	.046
84	8.1540	.034
85	6.5920	.023
86	.8120	.011

20.9478 5.6377

HISTOGRAM 4

```
FREQUENCY      0   1   0   2   3   2   6  12  24  16  14   1   3   1   1
------------------------------------------------------------------------
          24                                   *
          23                                   *
          22                                   *
          21                                   *
          20                                   *
          19                                   *
          18                                   *
          17                                   *
          16                                   *   *
          15                                   *   *
          14                                   *   *   *
          13                                   *   *   *
          12                               *   *   *   *
          11                               *   *   *   *
          10                               *   *   *   *
           9                               *   *   *   *
           8                               *   *   *   *
           7                               *   *   *   *
           6                           *   *   *   *   *
           5                           *   *   *   *   *
           4                           *   *   *   *   *
           3                   *       *   *   *   *   *       *
           2               *   *   *   *   *   *   *   *       *
           1       *       *   *   *   *   *   *   *   *   *   *   *   *
------------------------------------------------------------------------

INTERVAL       1   2   3   4   5   6   7   8   9  10  11  12  13  14  15
CLASS
```

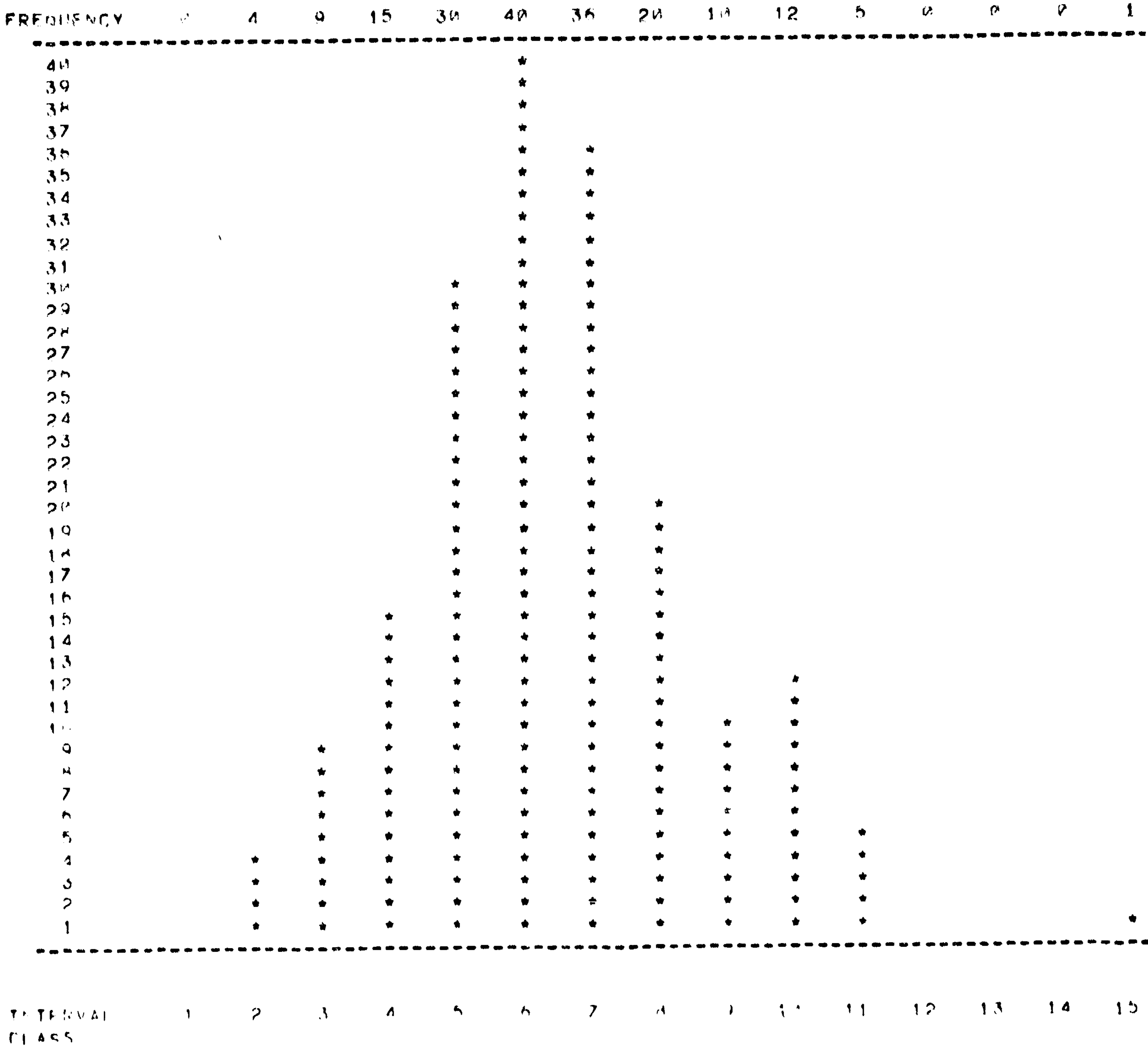
1	21.8080	.995
2	17.1390	.989
3	17.0230	.984
4	16.7390	.978
5	16.4550	.973
6	16.3390	.967
7	15.5580	.962
8	15.4600	.956
9	15.2650	.951
10	15.0700	.945
11	14.9720	.940
12	14.8740	.934
13	14.8740	.929
14	14.7950	.923
15	14.6970	.918
16	14.5810	.913
17	14.4040	.907
18	14.3860	.902
19	14.3672	.896
20	14.1110	.891
21	13.8980	.885
22	13.8000	.880
23	13.7210	.874
24	13.5070	.869
25	13.3121	.863
26	13.2140	.858
27	13.2140	.852
28	12.9210	.847
29	12.8420	.842
30	12.8230	.836
31	12.8230	.831
32	12.8230	.825
33	12.3540	.820
34	12.3350	.814
35	12.2560	.8[illegible]
36	12.0610	.803
37	11.9630	.798
38	11.9450	.792
39	11.7680	.787
40	11.7490	.781
41	11.6700	.776
42	11.67[illegible]	.77[illegible]
43	11.5720	.765
44	11.5543	.760
45	11.4563	.754
46	11.3773	.749
47	11.3590	.743
48	11.3590	.738
49	11.2790	.732
50	11.2610	.727
51	11.1820	.721
52	11.0840	.716
53	11.[illegible]66[illegible]	.71[illegible]
54	10.966[illegible]	.7[illegible]
55	10.986[illegible]	.69[illegible]
56	1[illegible].988[illegible]	.694
57	1[illegible].988[illegible]	.6[illegible]
58	10.8[illegible]0[illegible]	.683
59	1[illegible].880	.67[illegible]
60	10.87[illegible]	.672
61	1[illegible].773	.667
62	1[illegible].773	.661
63	1[illegible].[illegible]3[illegible]	.65[illegible]

64	10.5960	.650
65	10.5960	.645
66	10.5960	.639
67	10.4980	.634
68	10.4980	.628
69	10.4000	.623
70	10.3820	.617
71	10.3820	.612
72	10.3030	.607
73	10.2840	.601
74	10.2840	.596
75	10.2050	.590
76	10.2050	.585
77	10.2050	.579
78	10.1870	.574
79	10.1870	.568
80	10.1070	.563
81	10.0890	.557
82	10.0890	.552
83	9.9120	.546
84	9.9120	.541
85	9.8140	.536
86	9.7960	.530
87	9.7960	.525
88	9.7170	.519
89	9.6980	.514
90	9.6980	.508
91	9.6190	.503
92	9.6190	.497
93	9.6190	.492
94	9.6010	.486
95	9.6010	.481
96	9.6010	.475
97	9.5210	.470
98	9.5030	.464
99	9.5030	.459
100	9.4060	.454
101	9.4060	.448
102	9.3260	.443
103	9.3260	.437
104	9.308	.432
105	9.3080	.426
106	9.3080	.421
107	9.2290	.415
108	9.2100	.410
109	9.2100	.404
110	9.1130	.399
111	8.9350	.393
112	8.9360	.388
113	8.9170	.383
114	8.8380	.377
115	8.8200	.372
116	8.7400	.366
117	8.6430	.361
118	8.6240	.355
119	8.6240	.350
120	8.5450	.344
121	8.5450	.339
122	8.5270	.333
123	8.4290	.328
124	8.4290	.322
125	8.2520	.317
126	8.2340	.311

127	8.1360	.306
128	8.0380	.301
129	8.0380	.295
130	7.9410	.290
131	7.9410	.284
132	7.8610	.279
133	7.8430	.273
134	7.7450	.268
135	7.7450	.262
136	7.7450	.257
137	7.6660	.251
138	7.5500	.246
139	7.5500	.241
140	7.4520	.235
141	7.4520	.230
142	7.3730	.224
143	7.3550	.219
144	7.2750	.213
145	7.2750	.208
146	7.1780	.202
147	7.1590	.197
148	7.0800	.191
149	7.0800	.186
150	6.9640	.180
151	6.8850	.175
152	6.8850	.169
153	6.8850	.164
154	6.8850	.158
155	6.6890	.153
156	6.5920	.148
157	6.4760	.142
158	6.2810	.137
159	6.2210	.131
160	6.1040	.126
161	6.0060	.120
162	6.0060	.115
163	5.9880	.109
164	5.9080	.104
165	5.8110	.098
166	5.7920	.093
167	5.7130	.087
168	5.6350	.082
169	5.4220	.077
170	4.9320	.071
171	4.9130	.066
172	4.8160	.060
173	4.8160	.055
174	4.6390	.049
175	4.4250	.044
176	4.4250	.038
177	4.0530	.033
178	4.0530	.027
179	3.0760	.022
180	2.6670	.016
181	2.4900	.011
182	2.3930	.005

0.7639 3.1736

HISTOGRAM 5


FREQUENCY 0 4 9 15 30 40 36 20 10 12 5 0 0 0 1
40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
INTERVAL CLASS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

A P P E N D I X

C

PROGRAM ONE

```
      DIMENSION JJJJ(200),VALUE(200),GSR(200),Y(5,2,6)
      DIMENSION TK(5,2),TJK(5),TIK(2),TTJ(6),TI(2,6),TJ(5,6)
      INTEGER HPT
      LOGICAL SENSW
      HPT=44
      F=4.45
      IPN=15
      READ(HPT) Y
   09 DO 12 IX=1,5
      WRITE(IPN,666)
      DO12 JX=1,2
      H=0.
      DO 12 KX=1,6
      TK(IX,JX)=H+Y(IX,JX,KX)
      H=TK(IX,JX)
   12 CONTINUE
      WRITE(IPN,666)
      DO 20 IX=1,5
      H=0.
      DO20 JX=1,2
      TJK(IX)=H+TK(IX,JX)
      H=TJK(IX)
   20 CONTINUE
      WRITE(IPN,666)
      DO 30 JX=1,2
      H=0.
      DO 30 IX=1,5
      TIK(JX)=TK(IX,JX)+H
   30 CONTINUE
      WRITE(IPN,666)
      DO 40 JX=1,2
      DO 40 KX=1,6
      H=0.
      DO 40 IX=1,5
      TI(JX,KX)=H+Y(IX,JX,KX)
      H=TI(JX,KX)
   40 CONTINUE
      WRITE(IPN,666)
      DO 50 KX=1,6
      H=0.
      DO50 JX=1,2
      TTJ(KX)=H+TI(JX,KX)
      H=TTJ(KX)
   50 CONTINUE
      WRITE(IPN,666)
  666 FORMAT(1 [illegible],4HHERE)
      [illegible] IX=1,5
      [illegible] KX=1,6
      H=0.
      [illegible] JX=1,2
      TJ(IX,KX)=H+Y(IX,JX,KX)
      H=TJ(IX,KX)
    [illegible] CONTINUE
      WRITE(IPN,666)
      H=0.
      [illegible] 7[illegible] [illegible]=1,2
```

```
      TIJK=TIK(JX)+H
      H=TIK(JX)
   70 CONTINUE
      WRITE(IPN,666)
      H=0.
      DO 80 IX=1,5
      TJK2=TJK(IX)**2/12.+H
      H=TJK2
   80 CONTINUE
      WRITE(IPN,666)
      H=0.
      DO 81 JX=1,2
      TIK2=TIK(JX)**2/30.+H
      H=TIK2
   81 CONTINUE
      WRITE(IPN,666)
      H=0.
      DO 82 KX=1,6
      TIJ2=TIJ(KX)**2/12.+H
      H=TIJ2
   82 CONTINUE
      WRITE(IPN,666)
      H=0.
      TIJK2=TIJK**2/60.

      DO 83 IX=1,5
      DO 83 JX=1,2
      TK2=TK(IX,JX)**2/6.+H
      H=TK2
   93 CONTINUE
      WRITE(IPN,666)
      H=0.
      DO 84 IX=1,5
      DO 84 KX=1,6
      TJ2=TJ(IX,KX)**2/2.+H
      H=TJ2
   84 CONTINUE
      H=0.
      DO 85 JX=1,2
      DO 85 KX=1,5
      TI2=TI(JX,KX)**2/5.+H
      H=TI2
   85 CONTINUE
      H=0.
      DO 86 IX=1,5
      DO 86 JX=1,2
      DO 86 KX=1,6
      Y2=Y(IX,JX,KX)**2+H
      H=Y2
   86 CONTINUE
      H=0.
      T=TIJK/60.
      DO 87 IX=1,5
      DO 87 JX=1,2
      DO 87 KX=1,6
      T[illegible]A)=(TJK(IX)/12.-T)*(TIK(JX)/30.-T)*(TIJ(KX)/12.-T)*Y(IX,JX,KX)+H
      H=T[illegible]A
   87 CONTINUE
```

```
      SSS=TJK2-TIJK2
      SSC=TIK2-TIJK2
      SSF=TIJ2-TIJK2
      SSSC=TK2-TJK2-TIK2+TIJK2
      SSSF=TJ2-TIK2-TIJ2+TIJK2
      SSCF=TI2-TIK2-TIJ2+TIJK2
      SSSFC=Y2-TK2-TJ2-TI2+TJK2+TIK2+TIJ2-TIJK2
      SSNAD=60.**2*(TNAD**2)/(SSS*SSC*SSF)
      SSBAL=SSSFC-SSNAD
      XSS=SSS/4.
      XSC=SSC/1.
      XSF=SSF/5.
      XSSC=SSSC/4.
      XSSF=SSSF/20.
      XSCF=SSCF/5.
      XSSFC=SSSFC/18.
      XSNAD=SSNAD/1.
      XSBAL=SSBAL/17.
      FT=XSNAD/XSBAL
      IF(FT-F)89,89,88
   89 FS=XSS/XSSFC
      FC=XSC/XSSFC
      FF=XSF/XSSFC
      FSC=XSSC/XSSFC
      FSF=XSSF/XSSFC
      FCF=XSCF/XSSFC
      WRITE(IPR,555)
  555 FORMAT(1H1,42X,33HHYPOTHESIS OF ADDITIVITY ACCEPTED)
      WRITE(IPR,554)
  554 FORMAT(///,23X,6HSOURCE,13X,2HDF,13X,2HSS,16X,2HMS,17X,1HF)
      WRITE(IPR,553) SSS,XSS,FS
      WRITE(IPR,552) SSC,XSC,FC
      WRITE(IPR,551) SSF,XSF,FF
      WRITE(IPR,550) SSSC,XSSC,FSC
      WRITE(IPR,549) SSSF,XSSF,FSF
      WRITE(IPR,548) SSCF,XSCF,FCF
      WRITE(IPR,547) SSSFC,XSSFC
      WRITE(IPR,546) SSNAD,XSNAD
      WRITE(IPR,545) SSBAL,XSBAL
  545 FORMAT(/,20X,7HBALANCE,9X,2H17,2(7X,F11.6))
  546 FORMAT(/,23X,6HNONADD,11X,1H1,2(7X,F11.6))
  547 FORMAT(/,24X,3HSCF,15X,2H18,2(7X,F11.6))
  548 FORMAT(/,24X,2HCF,17X,1H5,3(7X,F11.6))
  549 FORMAT(/,24X,2HSF,16X,2H20,3(7X,F11.6))
  550 FORMAT(/,24X,2HSC,17X,1H4,3(7X,F11.6))
  551 FORMAT(/,24X,1HF,18X,1H5,3(7X,F11.6))
  552 FORMAT(/,24X,1HC,18X,1H1,3(7X,F11.6))
  553 FORMAT(/,24X,1HS,18X,1H4,3(7X,F11.6))
      GO TO 444
   88 WRITE(IPR,100)
  100 FORMAT(1H1,42X,33HHYPOTHESIS OF ADDITIVITY REJECTED)
  444 WRITE(IPR,111)
  111 FORMAT(1H1)
      DO 333 I=1,5
      DO 333 J=1,2
      DO 333 K=1,5
  333 WRITE(IPR,334) I,J,K,Y(I,J,K)
  334 FORMAT(14X,2(I1,1H,),I1,5X,F5.3)
```

S C F	
1,1,1	.091
1,1,2	.084
1,1,3	.074
1,1,4	.086
1,1,5	.102
1,1,6	.086
1,2,1	.091
1,2,2	.079
1,2,3	.071
1,2,4	.068
1,2,5	.067
1,2,6	.070
2,1,1	.050
2,1,2	.051
2,1,3	.050
2,1,4	.050
2,1,5	.063
2,1,6	.051
2,2,1	.056
2,2,2	.053
2,2,3	.055
2,2,4	.054
2,2,5	.056
2,2,6	.054
3,1,1	.059
3,1,2	.060
3,1,3	.052
3,1,4	.055
3,1,5	.057
3,1,6	.063
3,2,1	.069
3,2,2	.070
3,2,3	.066
3,2,4	.062
3,2,5	.064
3,2,6	.059
4,1,1	.051
4,1,2	.046
4,1,3	.054
4,1,4	.043
4,1,5	.049
4,1,6	.045
4,2,1	.062
4,2,2	.050
4,2,3	.05[illegible]
4,2,4	.058
4,2,5	.050
4,2,6	.053
5,1,1	.090
5,1,2	.099
5,1,3	.093
5,1,4	.10[illegible]
5,1,5	.115
5,1,6	.11[illegible]
5,2,1	.102
5,2,2	.073
5,2,3	.087
5,2,4	.091
5,2,5	.072
5,2,6	.093

HYPOTHESIS OF ADDITIVITY ACCEPTED

SOURCE	DF	SS	MS	F	$F^{.05}_{DF,DF}$
S	4	.274545	.068636	1653.646729	2.93
C	1	.000159	.000159	3.833486	4.41
F	5	.258067	.051613	1243.518799	2.77
SC	4	.001382	.000345	8.321779	2.93
SF	20	.017314	.000866	20.857750	2.19
CF	5	.000576	.000115	2.773768	2.77
SC⁻	18	.000747	.000042		
NONADD	1	.000154	.000154		
BALANCE	17	.000593	.000035		

Table 1

PROGRAM TWO

```
      DIMENSION XMEN(2,6)
      DIMENSION XMEAN(5,2),XSTD(5,2),Y(5,2,6),TOTI(2,6),TOTIJ(6)
      DIMENSION TOTIK(2),X(6)
      INTEGER HPT
      HPT=4
      YPN=16
      READ(HPT) Y
      DO 13 I=1,5
      DO 13 J=1,2
      DO 12 K=1,6
   12 X(K)=Y(I,J,K)
      XMEAN(I,J)=PMEAN(X,6)
      XSTD(I,J)=PVAR(X,6,1,XMEAN(I,J))
   13 XSTD(I,J)=SQRT(XSTD(I,J))
      DO 14 I=1,5
      DO 14 J=1,2
      DO 14 K=1,6
   14 Y(I,J,K)=(Y(I,J,K)-XMEAN(I,J))/XSTD(I,J)*6.**.5
      HH=0.
      DO 20 J=1,2
      DO 20 K=1,6
      H=0.
      DO 15 I=1,5
      TOTI(J,K)=Y(I,J,K)+H
   15 H=TOTI(J,K)
      T2I=TOTI(J,K)**2/5.+HH
   20 HH=T2I
      HH=0.
      DO 21 K=1,6
      H=0.
      DO 16 J=1,2
      TOTIJ(K)=TOTI(J,K)+H
   16 H=TOTIJ(K)
      T2IJ=TOTIJ(K)**2/10.+HH
   21 HH=T2IJ
      HH=0.
      DO22 J=1,2
      H=0.
      DO17 K=1,6
      TOTIK(J)=TOTI(J,K)+H
   17 H=TOTIK(J)
      T2IK=TOTIK(J)**2/30.+HH
   22 HH=T2IK
      H=0.
      DO 18 J=1,2
      TOTAL=TOTIK(J)+H
   18 H=TOTAL
      TOTAL=TOTAL**2/60.
      H=0.
      DO19 I=1,5
      DO19 J=1,2
      DO 19 K=1,6
      Y2=Y(I,J,K)**2+H
   19 H=Y2
      SSC=T2IK-TOTAL
      SSE=T2IJ-TOTAL
```

```
      SSCF=T2I-T2IK-T2IJ+TOTAL
      ERROR=Y2-T2I
      XSC=SSC/1.
      XSF=SSF/5.
      XSCF=SSCF/5.
      XSER=ERROR/48.
      FC=XSC/XSER
      FF=XSF/XSER
      FCF=XSCF/XSER
      WRITE(IPN,554)
  554 FORMAT(///,23X,6HSOURCE,13X,2HDF,13X,2HSS,16X,2HMS,17X,1HF)
      WRITE(IPN,552) SSC,XSC,FC
      WRITE(IPN,551) SSF,XSF,FF
      WRITE(IPN,548) SSCF,XSCF,FCF
      WRITE(IPN,547) ERROR,XSER
  547 FORMAT(/,24X,5HERROR,13X,2H48,2(7X,F11.6))
  548 FORMAT(/,24X,2HCF,17X,1H5,3(7X,F11.6))
  551 FORMAT(/,24X,1HF,18X,1H5,3(7X,F11.6))
  552 FORMAT(/,24X,1HC,18X,1H1,3(7X,F11.6))
  444 WRITE(IPN,111)
  111 FORMAT(1H1)
      DO 333 I=1,5
      DO 333 J=1,2
      DO 333 K=1,6
      WRITE(IPN,330) I,J,K,Y(I,J,K)
  330 FORMAT(10X,2(I1,1H,),I1,5X,F5.3)
  333 CONTINUE
      DO 28 J=1,2
      DO 28 K=1,6
      DO 10 I=1,5
   10 X(I)=Y(I,J,K)
   28 YMEAN(J,K)=AMEAN(X,5)
      WRITE(IPN,111)
      DO 30 J=1,2
      DO 30 K=1,6
   30 WRITE(IPN,32) J,K,YMEAN(J,K)
   32 FORMAT(10X,I1,1H,,I1,5X,F5.3)
      END
```

1,1,1	1.119
1,1,2	-.901
1,1,3	-3.54
1,1,4	-.250
1,1,5	3.903
1,1,6	-.331
1,2,1	4.490
1,2,2	1.135
1,2,3	-.879
1,2,4	-1.65
1,2,5	-1.91
1,2,6	-1.18
2,1,1	-1.76
2,1,2	-.630
2,1,3	-1.13
2,1,4	-1.25
2,1,5	4.980
2,1,6	-.892
2,2,1	2.598
2,2,2	-2.80
2,2,3	1.402
2,2,4	-2.34
2,2,5	2.532
2,2,6	-1.58
3,1,1	.860
3,1,2	1.293
3,1,3	-3.43
3,1,4	-1.82
3,1,5	-.333
3,1,6	3.400
3,2,1	2.112
3,2,2	3.070
3,2,3	.624
3,2,4	-1.76
3,2,5	-.552
3,2,6	-3.59
4,1,1	1.691
4,1,2	-.097
4,1,3	3.619
4,1,4	-3.12
4,1,5	.539
4,1,6	-1.72
4,2,1	3.505
4,2,2	-2.16
4,2,3	-1.75
4,2,4	2.463
4,2,5	-1.74
4,2,6	-.377
5,1,1	-1.09
5,1,2	-1.23
5,1,3	-2.78
5,1,4	-.861
5,1,5	3.744
5,1,6	2.234
5,2,1	3.199
5,2,2	-2.75
5,2,3	.178
5,2,4	.064
5,2,5	-3.72
5,2,6	1.438

1,1	.301
1,2	-.489
1,3	-1.45
1,4	-1.47
1,5	2.566
1,6	.55[illegible]
2,1	3.199
2,2	-.701
2,3	-.089
2,4	-.406
2,5	-.942
2,6	-1.06

R1/ [illegible]

SOURCE	DF	SS	MS	F	$F^{.05}_{DF,DF}$
C	1	.[illegible]	.[illegible]	.[illegible]	
F	5	55.2[illegible]233	11.24[illegible]46	3.[illegible]72	2.42
CF	5	65.860474	13.172[illegible]4	[illegible].553254	2.42
ERROR	48	177.93[illegible]477	3.7[illegible]51		

Table 2

PAGE 1

PROGRAM THREE

```
      DIMENSION VALUE(200),GSR(200),X(200)
      LOGICAL SE[illegible]S[illegible]
      INTEGER [illegible]PT
      IR[illegible]=15
      [illegible]PT=[illegible]
    1 READ([illegible]PT,2)
      [illegible]=[illegible]
      [illegible]=[illegible]
    2 FORMAT(I3)
      READ([illegible]PT,3) X(1),VALUE(1),GSR(1)
      DO 2[illegible] I=2,[illegible]
      READ([illegible]PT,3) X(I),VALUE(I),GSR(I)
    3 FORMAT(I3,2(F1[illegible].3))
      J=I-1
      IF(VALUE(J)-VALUE(I))1[illegible],1[illegible],6
   1[illegible] IF(GSR(I)-GSR(J))11,11,7
   11 [illegible] = [illegible]+1
      [illegible] T[illegible] [illegible]
    6 IF(GS[illegible](I)-[illegible](I))7,7,11
    7 [illegible] = [illegible]+1
   2[illegible] [illegible]T[illegible] [illegible]
      [illegible]TTE(IR[illegible],1[illegible]) [illegible]
   13 F[illegible]MAT(1[illegible] [illegible] =,I3,2[illegible]X,2[illegible] =,I3)
   [illegible] IF(.[illegible]T.[illegible](1)) [illegible] T[illegible] [illegible]
      IF([illegible] (3)) [illegible] T[illegible] 1
      E[illegible]
```

```
$EX,HTCT[illegible]
IP
LI
IP
[illegible]
.I
IP
IP
IP
$AS,H1,5
$EX,*
        = [illegible]          = [illegible]
        = [illegible]          = [illegible]
        = [illegible]          = [illegible]
        = [illegible]          = [illegible]
        = [illegible]7         = 57
        = [illegible]          = [illegible]
        = [illegible]          = [illegible]
        = [illegible]          = [illegible]
        = [illegible]          = [illegible]
        = [illegible]          = [illegible]2
 [illegible]
```

PROGRAM - AVG

```
      DIMENSION JJIJ(200),VALUE(200),GSR(200),Y(5,2,6)
      DIMENSION G(5,2,6), GX(2,6),XMEAN(5,2),XSTD(5,2),X(6)
      INTEGER HPT
      LOGICAL SENSW
      HPT=40
      IPR=16
      I=0
    8 I=I+1
      J=0
    9 J=J+1
      READ(HPT,5) N
      WRITE(IPR,5) N
    5 FORMAT(I3)
      K=0
      M=0
      NN=0
   10 K=K+1
      YM=0.
      TOTAL=0.
      TOT=0.
   11 NN=NN+1
      YM=YM+1.
      M=M+1
      IF(M-N)16,16,14
   16 READ(HPT,4) JJIJ(NN),VALUE(NN),GSR(NN)
    4 FORMAT(I3,2(F12.3))
      TOTAL=VALUE(NN)+TOTAL
      TOT=GSR(NN)+TOT
      IF(TOTAL-275.)11,13,13
   13 Y(I,J,K)=YM/TOTAL
      G(I,J,K)=TOT/YM
      IF(K-5)10,14,14
   14 IF(.NOT.SENSW(1)) GOTO 14
      IF(J-2)9,15,15
   15 IF(I-5)8,99,99
   99 WRITE(IPR,98)
   98 FORMAT(1H1)
      DO 77 I=1,5
      DO 77 J=1,2
      DO 77 K=1,6
      WRITE(IPR,78) I,J,K,Y(I,J,K),G(I,J,K)
   78 FORMAT(1X,I1,1H,,I1,1H,,I1,10X,F8.4,10X,F8.4)
   77 CONTINUE
      DO 3 I=1,5
      DO 3 J=1,2
      DO 2 K=1,6
    2 X(K)=G(I,J,K)
      XMEAN(I,J)=[illegible](X,5)
      XSTD(I,J)=[illegible](X,5,1,XMEAN(I,J))
    3 XSTD(I,J)=SQRT(XSTD(I,J))
      WRITE(IPR, 4)
      DO 44 I=1,5
      DO 44 J=1,2
      DO 44 K=1,5
      G(I,J,K)=(G(I,J,K)-XMEAN(I,J))/XSTD(I,J)*5.+.5
   44 WRITE(IPR,45)I,J,K,G(I,J,K)
```

```
   65 FORMAT(10X,I1,1H,,I1,1H,,I1,10X,F6.4)
      WRITE(IPN,98)
      DO 6 J=1,2
      DO 6 K=1,6
      TOT=0.
      DO 6 I=1,5
      GX(J,K)=TOT+G(I,J,K)/5.
    6 TOT=GX(J,K)
      DO 7 J=1,2
      DO 7 K=1,6
      WRITE(IPN,66) J,K,GX(J,K)
   66 FORMAT(10X,I1,1H,,I1,10X,F6.4)
    7 CONTINUE
      END
```

1,1,1	.0913	.1414
1,1,2	.0837	.1409
1,1,3	.0737	.1483
1,1,4	.0862	.1478
1,1,5	.1019	.1563
1,1,6	.0858	.1538
1,2,1	.0909	.1001
1,2,2	.0786	.0066
1,2,3	.0713	.0006
1,2,4	.0684	.0027
1,2,5	.0675	-.0003
1,2,6	.0702	-.0207
2,1,1	.0504	.1614
2,1,2	.0512	.1579
2,1,3	.0502	.1494
2,1,4	.0500	.1536
2,1,5	.0628	.1506
2,1,6	.0507	.1559
2,2,1	.0562	.1722
2,2,2	.0535	.1798
2,2,3	.0555	.1389
2,2,4	.0538	.1875
2,2,5	.0562	.1862
2,2,6	.0543	.1807
3,1,1	.0591	.1686
3,1,2	.0598	.1556
3,1,3	.0521	.1722
3,1,4	.0547	.1639
3,1,5	.0572	.1769
3,1,6	.0634	.1764
3,2,1	.0686	.1423
3,2,2	.0704	.1484
3,2,3	.0663	.1545
3,2,4	.0623	.1483
3,2,5	.0643	.1561
3,2,6	.0593	.1655
4,1,1	.05[illegible]9	.2[illegible]49
4,1,2	.0464	.2158
4,1,3	.0542	.2219
4,1,4	.0428	.2202
4,1,5	.0490	.2286
4,1,6	.0452	.2378
4,2,1	.0567	1.5[illegible]76
4,2,2	.0496	.1499
4,2,3	.0503	.1476
4,2,4	.0577	.1528
4,2,5	.0503	.1572
4,2,6	.0527	.1494
5,1,1	[illegible]	.2335
5,1,2	.0386	.1954
5,1,3	.0935	.1[illegible]77
5,1,4	.0397	.183[illegible]
5,1,5	.114[illegible]	[illegible]
5,1,6	.1[illegible]96	.177[illegible]
5,2,1	.1[illegible]16	.1451
5,2,2	.072[illegible]	.1483
5,2,3	.0671	.1526
5,2,4	[illegible]	.1472
5,2,5	.0716	.1447
5,2,6	.0931	.1379

1,1,1	-2.610
1,1,2	-2.809
1,1,3	.0853
1,1,4	-.1077
1,1,5	3.2060
1,1,6	2.2358
1,2,1	4.9889
1,2,2	-.7057
1,2,3	-1.070
1,2,4	-.9403
1,2,5	-1.123
1,2,6	-1.149
2,1,1	3.5645
2,1,2	1.6769
2,1,3	-2.924
2,1,4	-.6303
2,1,5	-2.275
2,1,6	.5903
2,2,1	-4.042
2,2,2	-1.077
2,2,3	2.4661
2,2,4	1.9330
2,2,5	1.4306
2,2,6	-.7292
3,1,1	-.8797
3,1,2	-2.253
3,1,3	.71[illegible]
3,1,4	-2.994
3,1,5	2.8151
3,1,6	2.5968
3,2,1	-3.112
3,2,2	-1.24[illegible]
3,2,3	.5972
3,2,4	-1.275
3,2,5	1.[illegible]798
3,2,6	3.9525
4,1,1	-[illegible].546
4,1,2	-1.243
4,1,3	.[illegible]745
4,1,4	-.2975
4,1,5	1.5576
4,1,6	3.5551
4,2,1	4.909[illegible]
4,2,2	-1.[illegible]
4,2,3	-1.[illegible]16
4,2,4	-.[illegible]35
4,2,5	-.9742
4,2,6	-1.[illegible]
5,1,1	4.5[illegible]
5,1,2	-.1[illegible]
5,1,3	.178
5,1,4	-1.537
5,1,5	-.[illegible]37
5,1,6	-2.374
5,2,1	-.4257
5,2,2	1.155
5,2,3	3.335[illegible]
5,2,4	.[illegible]235
5,2,5	-.[illegible]21[illegible]
5,2,6	-4.[illegible]71

1,1	.2064
1,2	-.9469
1,3	-.3742
1,4	-1.133
1,5	.9277
1,6	1.3206
2,1	.4814
2,2	-.5751
2,3	.6663
2,4	-.1295
2,5	-.2417
2,6	-.6013

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